Corridor System Management Plan (CSMP)

Los Angeles I-5 North Corridor

From I-10 to I-210

Final Report

September 2010

I approve this Corridor System Management Plan (CSMP) for the I-5 North Corridor in Caltrans District 7 as the overall Policy Statement and Strategic Plan that will guide transportation decisions and investment for the I-5 Corridor from I-10 to I-210 in Los Angeles County.

Approval

for [signature] 5/4/11

MICHAEL MILES Date
District 7 Director

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1. INTRODUCTION

This document represents the draft Final Report of the Los Angeles Interstate 5 (I-5) North Corridor System Management Plan (CSMP) developed by the California Department of Transportation (Caltrans). The I-5 North study corridor runs in a north-south direction from the I-10 Interchange (San Bernardino Freeway) at Post Mile 18.4 to the I-210 Interchange at Post Mile 44.0.

This final report contains the results of a two-year study that included several key steps, including:

- Stakeholder Involvement (discussed below in this Section 1)
- Corridor Description and Performance Assessment (Sections 2 and 3)
- Bottleneck Identification and Causality Analysis (Section 4)
- Scenario Development and Analysis (Section 5)
- Conclusions and Recommendations (Section 6).

This CSMP is the direct result of the November 2006 voter-approved Proposition 1B (The Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006). This ballot measure included a funding program deposited into a Corridor Mobility Improvement Account (CMIA). CMIA money is partially funding one project on the study corridor. The project will construct high occupancy vehicle (HOV) lanes in the median of I-5 from SR-134 to SR-170, a distance of approximately nine miles. Approximately, $73 million in CMIA funds have been adopted by the CTC for this project.

To receive CMIA funds, the California Transportation Commission (CTC) guidelines required that project sponsors describe in a CSMP how mobility gains from CMIA funded corridor improvements would be maintained over time. Therefore, a CSMP aims to define how corridors will be managed in the long term, focusing on operational strategies in addition to the already funded expansion projects. The goal is to get the most out of the existing system and maintain or improve corridor performance.

The I-5 CSMP involved corridor stakeholders in the study to discuss progress, technical challenges, data needs, and preliminary conclusions. Representatives from cities bordering I-5 were briefed at critical milestones. Feedback from stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis given their intimate knowledge of local conditions. Moreover, various stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

This report presents performance measurement findings, identifies bottlenecks that lead to less than optimal performance, and diagnoses the causes for these bottlenecks in detail. Alternative investment strategies were modeled using the year 2007 as the Base Year and 2020 as the Horizon Year.

This CSMP should be updated by Caltrans on a regular basis since corridor performance can vary dramatically over time due to changes in demand patterns, economic conditions, and delivery of projects and strategies among others. Such changes could influence the conclusions of the CSMP and the relative priorities in investments. Therefore, it is recommended that updates occur no less than every two to three years. To the extent possible, this document has been organized to facilitate such updates.

The following discussion provides background to the system management approach in general and CSMPs in particular.

What is a Corridor System Management Plan (CSMP)?

In November 2006, voters approved Proposition 1B. This ballot measure included a funding program that to be deposited into the CMIA. For a project to be nominated by a Caltrans district or regional agency, CTC guidelines for the CMIA require that the project nomination describe how mobility gains of urban corridor capacity improvements would be maintained over time.

The guidelines also stipulate that the CTC will give priority to project nominations that include a CSMP. A CSMP is a comprehensive plan for maintaining the congestion reduction and productivity improvements achieved on a CMIA corridor. CSMPs incorporate all travel modes - including state highways and freeways, parallel and connecting Roadways, public transit (bus, bus rapid transit, light rail, intercity rail), carpool/vanpool programs, and bikeways. CSMPs also include intelligent transportation technologies such as ramp metering, coordinated traffic signals, changeable message signs for traveler information, and improved incident management.

This CSMP is the first attempt to integrate the overall concept of system management into Caltrans' planning and decision making processes for the corridor. The traditional planning approach identified localized freeway problem areas and then developed solutions to fix those problems often by building expensive capital improvement projects. The I-5 CSMP focuses on the system management approach with a greater emphasis on using on-going performance assessments to identify operational strategies that yield higher congestion reduction and productivity benefits relative to the amount of money spent.

Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks to address the safety and mobility needs of bicyclists, pedestrians, and transit users in all projects, regardless of funding. Bicycle, pedestrian, and transit travel is facilitated by creating "complete streets" beginning early in system planning and continuing through project delivery, maintenance, and operations. Developing a network of complete streets requires collaboration among all Caltrans functional units and stakeholders. As the first-generation CSMP, this report focuses more on reducing congestion and increasing mobility through capital and operational strategies. Future CSMP work will further address pedestrian, bicycle and transit components and seek to manage and improve the whole network as an interactive system.

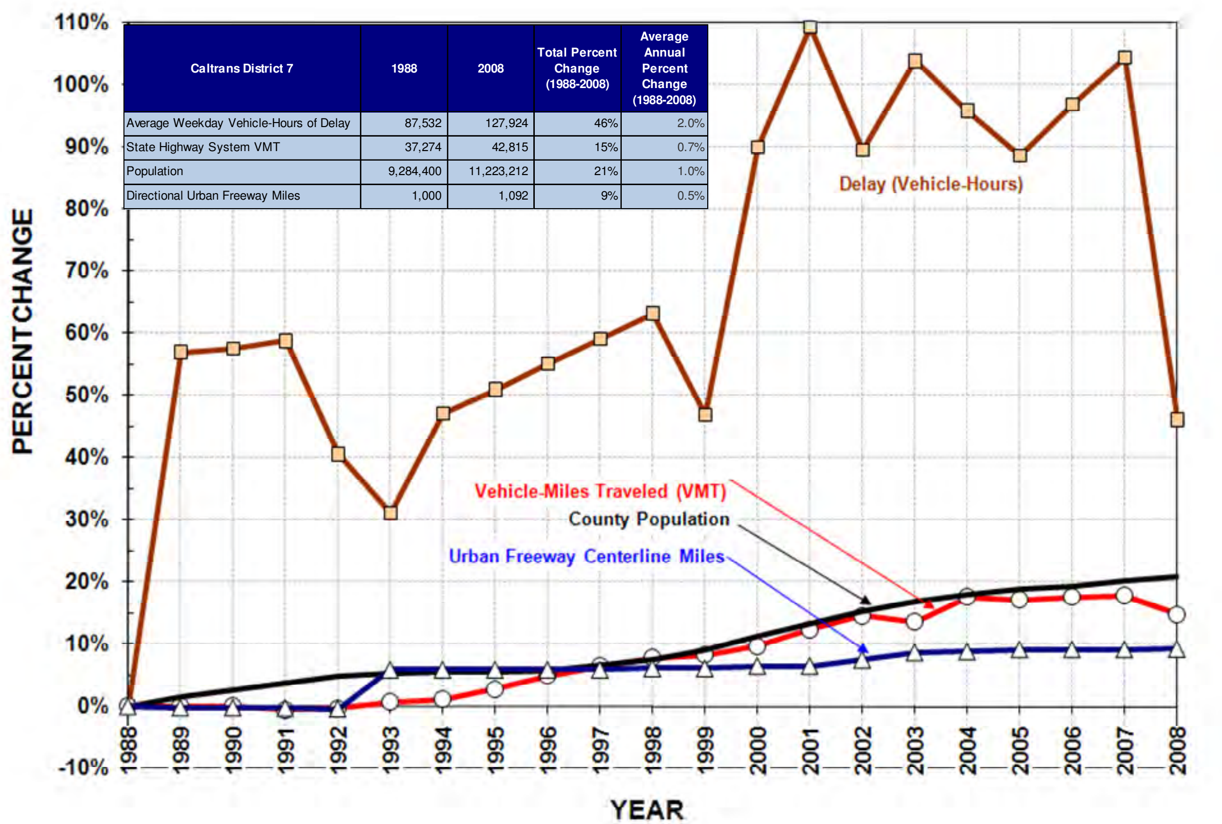
What is System Management?

With the rising cost and complexity of construction and right of way acquisition, the era of large-scale freeway construction is coming to an end. Compared to the growth of vehicle-miles traveled (VMT) and population, congestion is growing at a much higher rate.

Exhibit 1-1 shows Los Angeles congestion (measured by average weekday recurring vehicle-hours of delay), VMT, and population between 1988 and 2008. Over that 20-year period, congestion increased 50 percent from the 1988 congestion level (just under two percent per year). Over the same period, VMT and population rose by about 20 percent (one percent per year). However, urban freeway miles barely grew at less than one-half a percentage point per year.

Clearly, infrastructure expansion has not kept pace with demographic and travel trends and is not likely to keep pace in the future. Therefore, if conditions are to improve, or at least not deteriorate as fast, a new approach to transportation decision making and investment is needed.

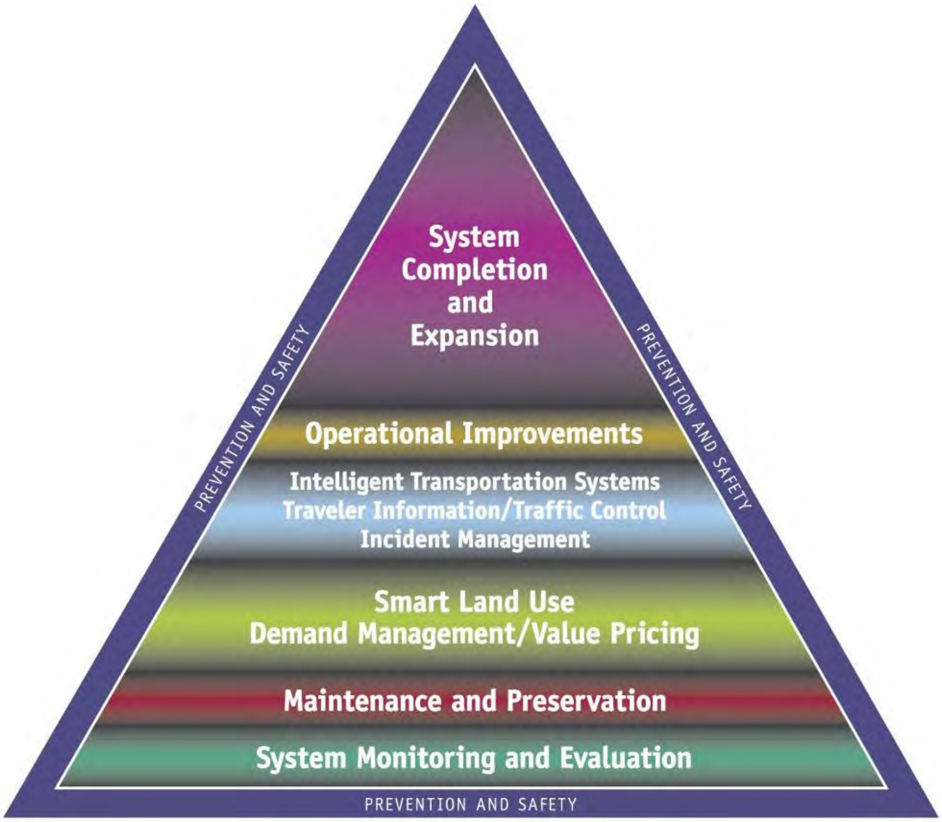
Exhibit 1-1: District 7 Growth Trends (1988-2008)



Caltrans District 7	1988	2008	Total Percent Change (1988-2008)	Average Annual Percent Change (1988-2008)
Average Weekday Vehicle-Hours of Delay	87,532	127,924	46%	2.0%
State Highway System VMT	37,274	42,815	15%	0.7%
Population	9,284,400	11,223,212	21%	1.0%
Directional Urban Freeway Miles	1,000	1,092	9%	0.5%

Caltrans recognizes this dilemma and has adopted a mission statement that embraces the concept of system management. This mission and its goals are supported by the system management approach illustrated in the System Management pyramid shown in Exhibit 1-2.

Exhibit 1-2: System Management Pyramid



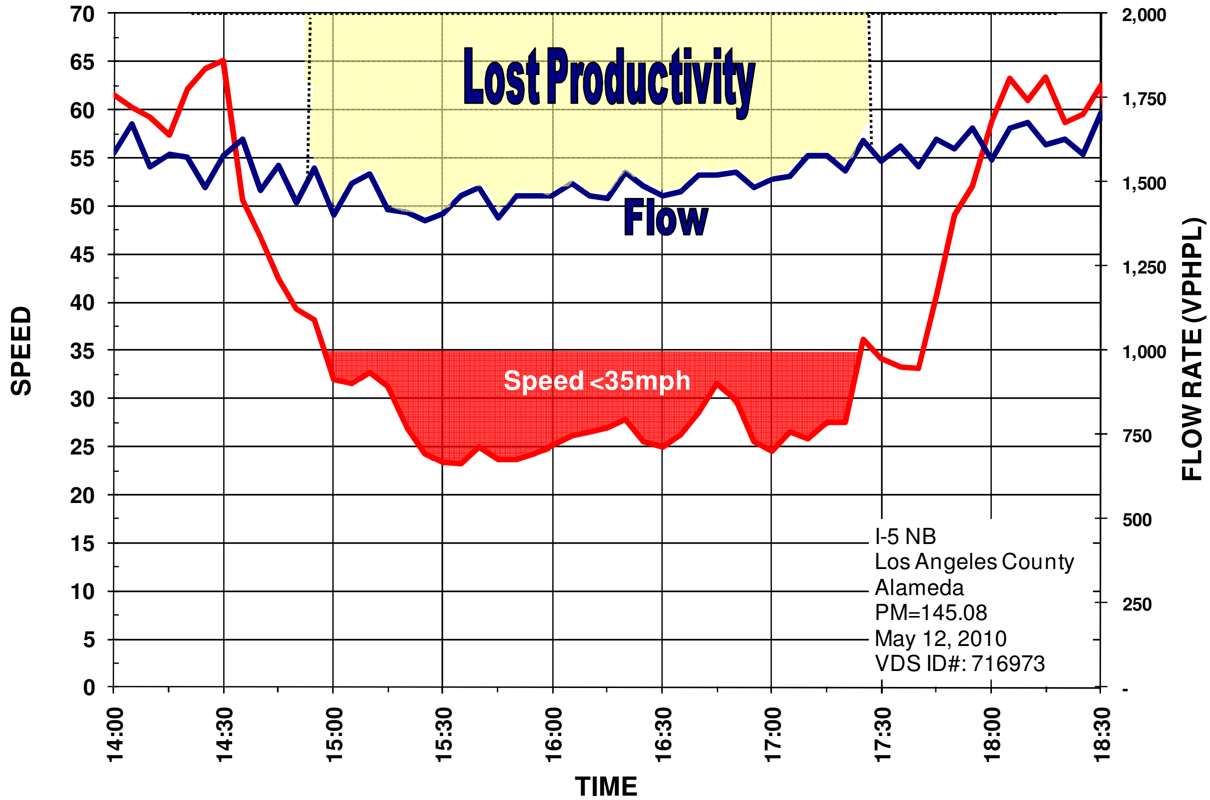
System Management is being touted at the federal, state, regional and local levels. It addresses both transportation demand and supply to get the best system performance possible. Ideally, Caltrans would develop a regional system management plan that addresses all components of the pyramid for an entire region comprehensively. However, because the system management approach is relatively new, it is prudent to apply it at the corridor level first.

The foundation of system management is monitoring and evaluation (shown as the base of the pyramid). This monitoring is done by comprehensive performance assessment and evaluation. Understanding how a corridor performs and why it performs the way it does is critical to crafting appropriate strategies. Section 3 is dedicated to performance assessment. It would be desirable for Caltrans to update this performance assessment every two or three years to ensure that future corridor issues can be identified and addressed before breakdown occurs on the corridor.

A critical goal of system management is to "get the most out" of the existing system, or maximize system productivity. One would think that a given freeway is most productive during peak commute times. Yet, this is not true for heavy commute corridors. In fact, for Los Angeles' urban freeways that have been experiencing growing congestion, the opposite is true. When demand is the highest, the flow breaks down and productivity declines.

Exhibit 1-3 illustrates how congestion leads to lost productivity. The exhibit was created using observed I-5 data from sensors for a typical spring 2010 afternoon peak period (Wednesday, May 12, 2010). It shows speeds (in red) and flow rates (in blue) on northbound I-5 at Alameda Avenue, one of the most congested locations on this corridor.

Exhibit 1-3: Productivity Loss During Congestion



Flow rates (measured as vehicle-per-hour-per-lane or “vphpl”) at Alameda Avenue average slightly over 1,600 vphpl between 2:00 PM and 3:00 PM, which is slightly less than a typical peak period maximum flow rate.

Once volumes exceed this maximum rate, traffic becomes unstable. Any additional merging or weaving, traffic breaks down and speeds rapidly plummet to below 35-mph. In essence, every incremental merge takes up two spots on the freeway for a short time. However, since the volume is close to the capacity, these merges lead to queues. Moreover, rather than accommodating the same number of vehicles, flow rates also drop and vehicles back up creating bottlenecks and associated congestion.

At the location shown in Exhibit 1-3, throughput drops by 10 percent during the peak period (from over 1,600 to around 1,400 vphpl). This five-lane road therefore operates as if it has lost 10 percent capacity when demand is at its highest. Just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost lanes. This loss in throughput can be aggregated and presented as "Equivalent Lost-Lane-Miles".

This is lost productivity. Where there is sufficient automatic detection, this loss in throughput can be quantified and presented as "Equivalent Lost Lane-Miles". Discussed in more detail later in this report, the productivity losses on northbound I-5 were over 8.0 daily lane-miles during the PM peak period in 2009. Caltrans works hard to recover this lost productivity by investing in improvements that utilize public funds in the most effective manner. By largely implementing operational strategies, Caltrans can leverage past investments and restore productivity.

Although still an important strategy, infrastructure expansion (at the top of the pyramid in Exhibit 1-2) cannot be the only strategy for addressing the mobility needs in Los Angeles County. System management must be an important consideration as Caltrans and its partners evaluate the need for facility expansion investments. The system management philosophy begins by defining how the system is performing, understanding why it is performing that way, and then evaluating different strategies, including operations centric strategies, to address deficiencies. Various tools can be used to estimate potential benefits to determine if these benefits are worthy of the costs to implement the strategy.

Stakeholder Involvement

The I-5 North Corridor CSMP involved corridor stakeholders including representatives from cities bordering I-5, the Southern California Association of Governments (SCAG), and the Los Angeles County Metropolitan Transportation Authority (Metro). Caltrans briefed stakeholders at critical milestones. Feedback from the stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis given their intimate knowledge of local conditions. Moreover, various stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

The stakeholders included representatives from the following organizations:

- Southern California Association of Governments (SCAG)
- Los Angeles County Metropolitan Transportation Authority (Metro)
- Los Angeles Department of Transportation (LADOT)
- City of Burbank
- City of Glendale.

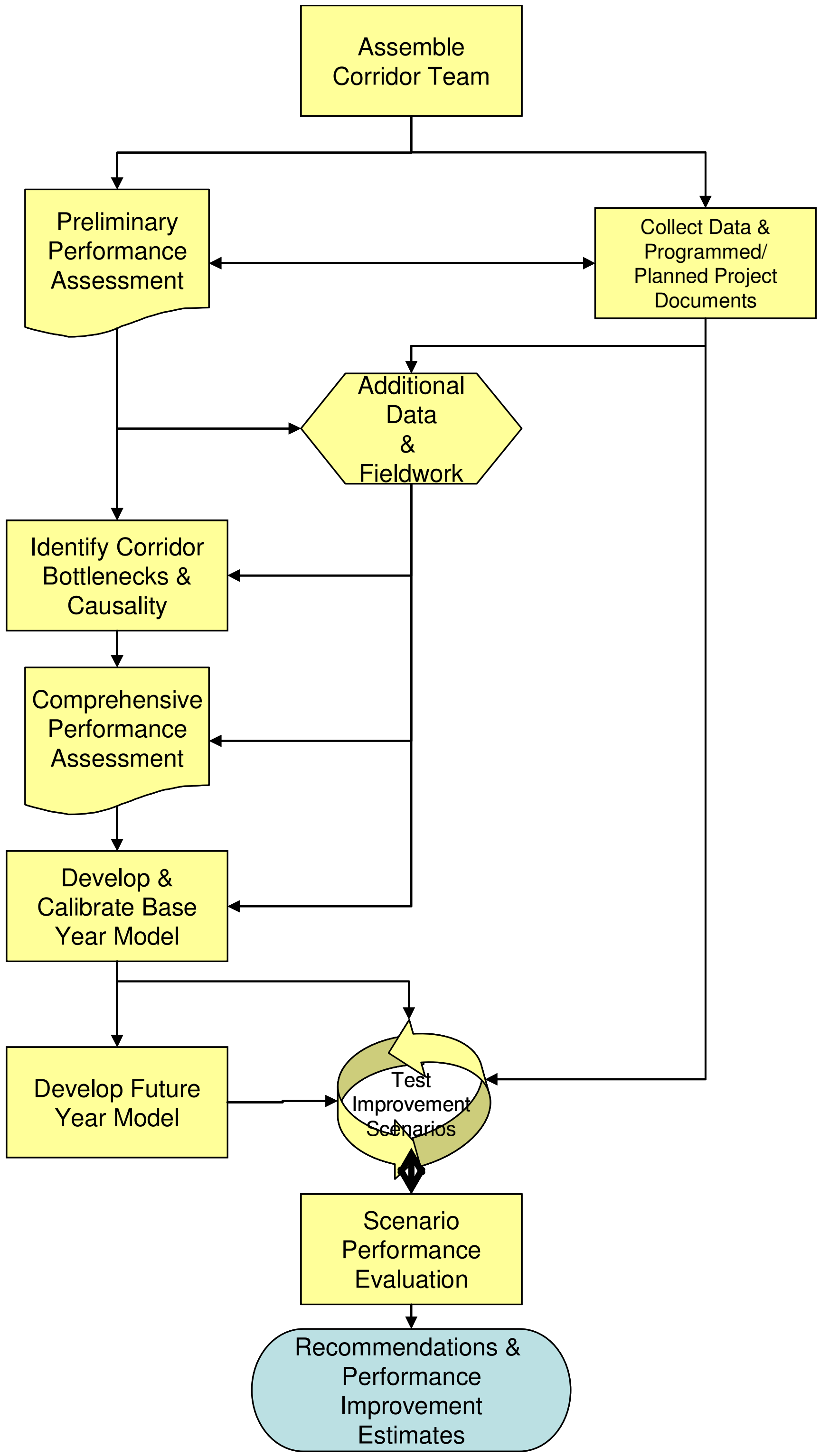
Caltrans would like to thank all of its partners for contributing to this CSMP development process. In addition, the CSMP development provided a venue for tighter coordination between Caltrans planning and operations professionals, which is critical to the success of the system management approach.

Study Approach

The I-5 CSMP study approach follows system management principles by placing an emphasis on performance monitoring and evaluation (the base of the pyramid in Exhibit 1-2), and on using lower cost operational improvements to maintain system productivity.

Exhibit 1-4 is a flow chart that illustrates this approach. Each step of the approach is described following the chart.

Exhibit 1-4: Study Approach



Assemble Corridor Team

The first task in this effort was undertaken by Caltrans with the creation of an I-5 CSMP team. The team met periodically to review project progress and to provide feedback to the study team.

In addition to the CSMP team, Caltrans also identified cities and other major stakeholders along the I-5 corridor (e.g., City of Burbank, City of Glendale, and Los Angeles Department of Transportation) whose input was solicited during the bottleneck identification and scenario development processes. The stakeholders group convened several times during the study period to receive local feedback on relevant issues and "buy off" at critical junctures.

Preliminary Performance Assessment

The Preliminary Performance Assessment Report presented a brief description of the corridor and existing projects along or adjacent to I-5. It included a corridor-wide performance assessment for four key performance areas: mobility, reliability, safety, and productivity. The assessment also included a preliminary bottleneck location assessment based on readily available existing data and limited field observations.

The results of the Preliminary Performance Assessment were updated and included in the Comprehensive Performance Assessment described below. The results of these two assessments are presented in the Corridor Description and Corridor Performance sections - Sections 2 and 3 of this final report.

For future I-5 CSMP reporting, the Preliminary Performance Assessment should not be necessary since its main purpose is to identify data gaps – particularly detection gaps. It is anticipated that these gaps will be addressed with improved automatic detection. Future updates to CSMPs can be made to this final report.

Collect Data and Programmed/Planned Project Information

In conjunction with the Preliminary Performance Assessment, SMG reviewed existing studies, plans and other programming documents to assess additional data collection needs for modeling and scenario development. One of the key elements of this study was to identify projects that would be implemented in the short- and long-term time frames to be included in the Vissim micro-simulation model developed by the modeling team.

Details of the projects included in the scenario analysis are discussed in Section 5: Scenario Development and Evaluation.

Additional Data Collection and Fieldwork

The study team determined locations where additional manual traffic counts would be needed to calibrate the 2007 Base Year model and coordinated the collection of the traffic count data. Traffic data counts collected included peak period turning movement counts and 24-hour average daily traffic (ADT) counts. In addition, signal timing data were obtained from Caltrans and various cities for use in the model calibration.

The study team conducted several field visits in September, October, and November 2008 to observe field conditions during peak periods and videotape potential bottleneck locations. This fieldwork will be discussed in Section 4: Bottleneck Identification and Causality Analysis.

Identify Corridor Bottlenecks and Causality

Building on the Preliminary Performance Assessment and the fieldwork, the study team identified major AM and PM peak period bottlenecks along the corridor. These bottlenecks will be discussed in detail in Section 4 of this report.

Comprehensive Performance Assessment

Once the bottlenecks were identified and the causality of the bottlenecks determined, SMG prepared a Comprehensive Performance Assessment, which was delivered to Caltrans in May 2009. This report builds on the Preliminary Performance Assessment with a discussion of bottleneck causality findings – including performance results for each individual bottleneck area. It also included corridor-wide performance results updated to reflect 2008 conditions.

Develop and Calibrate Base Year Model

Using the bottleneck areas as the basis for calibration, the modeling team developed a calibrated 2007 Base Year model for the corridor. This model was calibrated against California and Federal Highway Administration (FHWA) guidelines for model calibration. In addition, the model was evaluated to ensure that each bottleneck area was represented in the model and that travel times and speeds were consistent with observed data. This process required several review iterations and an independent model peer reviewer.

Discussion of the calibrated 2007 Base Year model can be found in Section 5: Scenario Development and Evaluation.

Develop Future Year Model

Following the approval of the 2007 Base Year model, the modeling team developed a 2020 Horizon Year model to be used to test the impacts of short-term programmed projects as well as future operational improvements including the impacts of improved incident management on the corridor.

Discussion of the 2020 Horizon Year model can be found in Section 5: Scenario Development and Evaluation.

Test Improvement Scenarios

The study team developed 11 scenarios that were evaluated using the micro-simulation model. Short-term scenarios included programmed projects that would likely be completed typically within the next five years along with other operational improvements such as improved ramp metering.

In addition to the short-term evaluations, short-term projects were also tested using the 2020 Horizon Year model to assess their long-term impacts. In addition, the study team developed and tested other scenarios using only the 2020 model. These scenarios included programmed and planned projects that would not be completed within five years of 2007 and that would likely only experience benefits in the long-term.

Scenario testing results are presented in Section 5: Scenario Development and Evaluation.

Scenario Performance Evaluations

Once scenarios were developed and fully tested, simulation results for each scenario were subjected to a benefit-cost evaluation to determine how much “bang for the buck” each scenario would deliver. The study team performed a detailed benefit-cost assessment using the California Benefit-Cost model (Cal-B/C).

The results of the benefit-cost analysis are presented in Section 5: Scenario Development and Evaluation.

Recommendations and Performance Improvement Estimates

The study team developed final recommendations for future operational improvements that could be reasonably expected to maintain the mobility gains achieved by existing programmed and planned projects. Section 6 summarizes these findings.

The remainder of this report is organized into six sections (Section 1 is this introduction):

2. _Corridor Description_ describes the corridor, including the roadway facility, recent improvements, major interchanges and relative demands at these interchanges, relevant transit services serving freeway travelers, major Intermodal facilities around the corridor, special event facilities/trip generators, and an I-5 origin-destination demand profile from the SCAG regional model.

3. _Corridor Performance Assessment_ presents multiple years (2005 to 2009) of performance data for the freeway portion of the I-5 corridor. Statistics are included for the mobility, reliability, safety, and productivity performance measures.

4. _Bottleneck Identification and Causality Analysis_ identifies bottlenecks, or choke points, on the I-5. It also diagnoses the bottlenecks and identifies the causes of each location through additional data analysis and field observations. This section has performance results for delay, productivity, and safety by major "bottleneck area", which allows for the relative prioritization of bottlenecks in terms of their contribution to corridor performance degradation. It also provides input to selecting projects to address the critical bottlenecks, and provides the baseline against which the micro-simulation models were validated.

5. _Scenario Development and Analysis_ discusses the scenario development approach and summarizes the expected future performance based on the Vissim micro simulation model developed by the modeling team for the corridor.

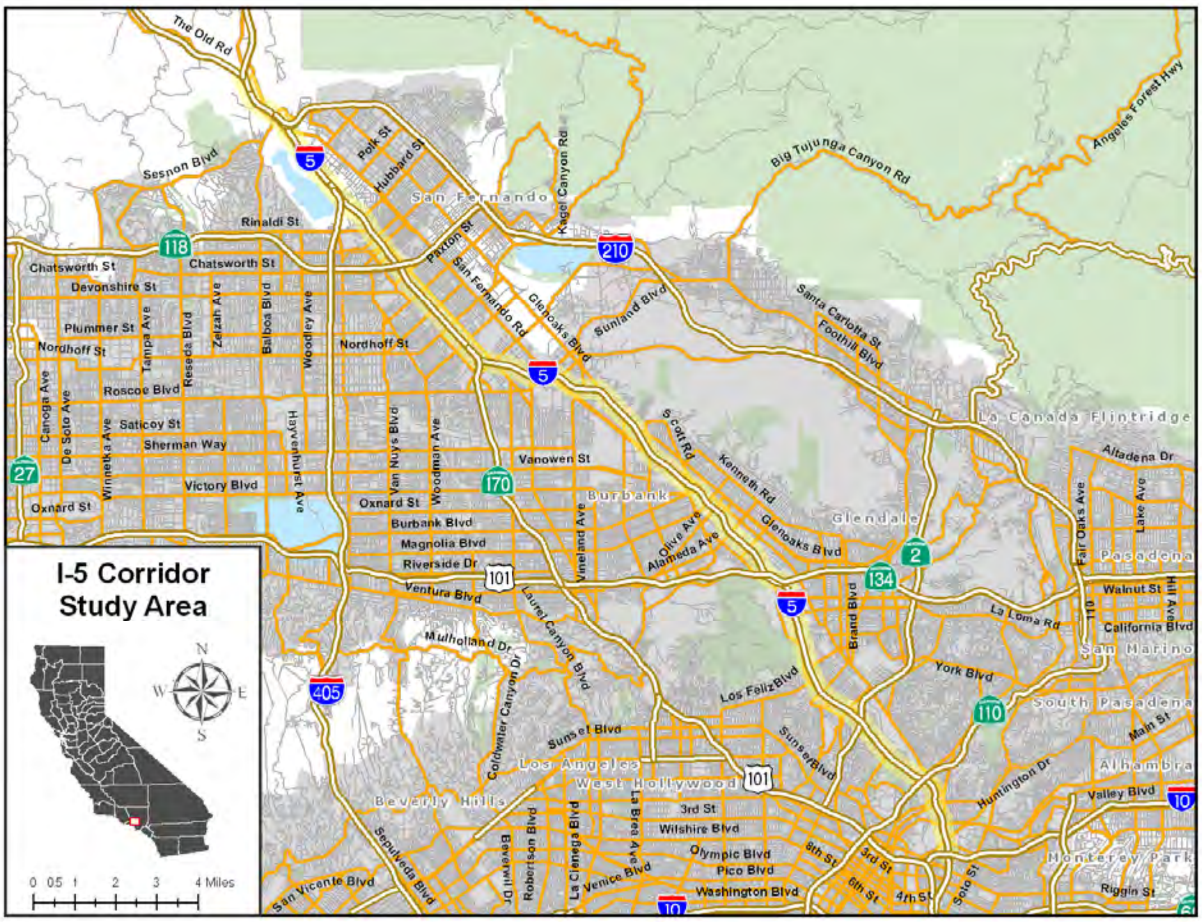
6. _Conclusions and Recommendations_ describes the projects and scenarios that were evaluated and recommends a phased implementation of the most promising set of strategies.

The appendices provide project lists for the micro-simulation scenarios and detailed benefit-cost results.

2. CORRIDOR DESCRIPTION

As shown in Exhibit 2-1, the Golden State Freeway (I-5) study corridor begins at the I-10 (San Bernardino Freeway) interchange and runs northwest to the I-210 (Foothill Freeway) interchange. The study corridor, as defined by Caltrans District 7, extends approximately 26 miles from the I-10 interchange at Post Mile (PM) 18.452 to the I-210 interchange at PM 44.014. It traverses the cities of Los Angeles, Glendale, Burbank, and San Fernando.

Exhibit 2-1: Los Angeles I-5 North CSMP Corridor Map



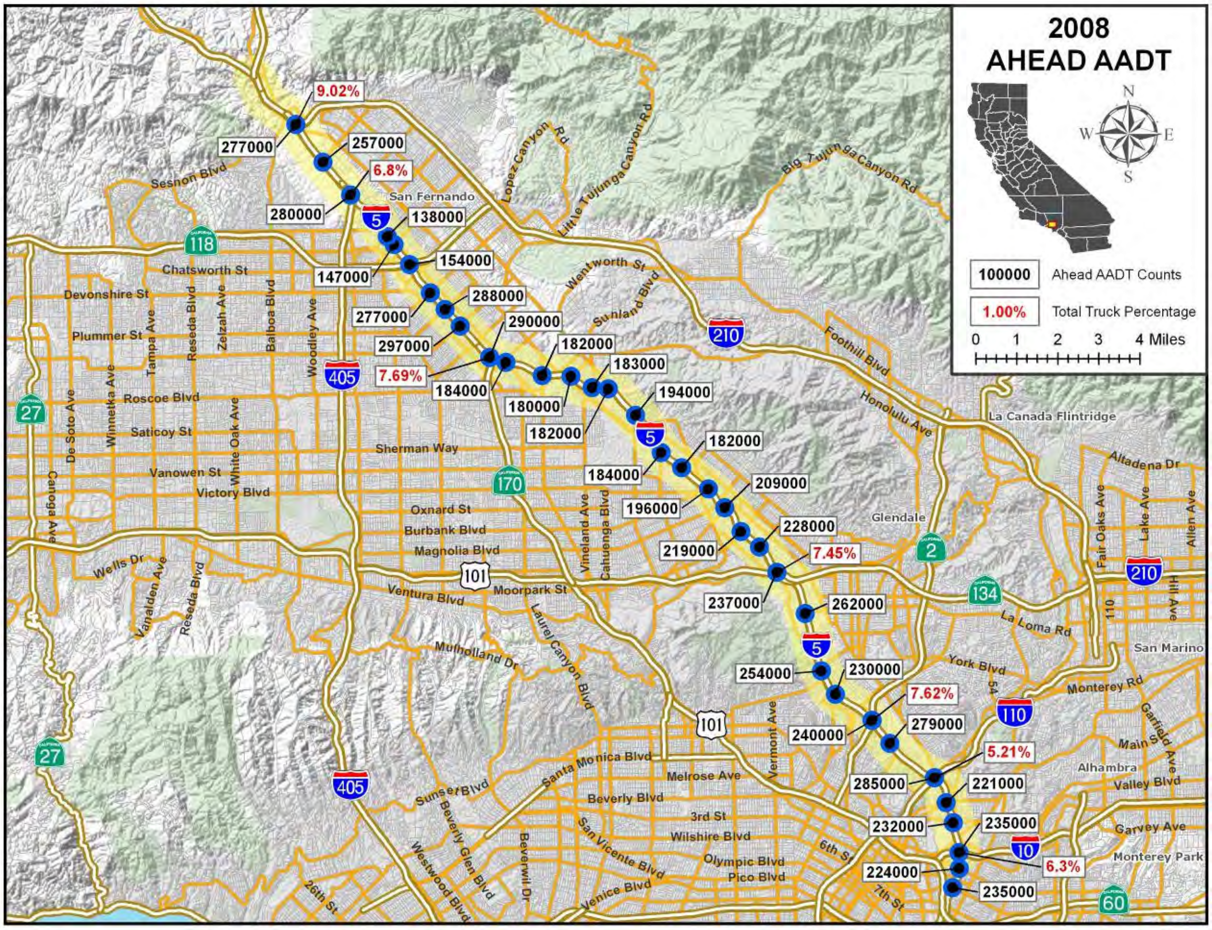
Corridor Roadway Facility

The study corridor crosses through Los Angeles County and includes the following eight major freeway-to-freeway interchanges:

- The San Bernardino Freeway (I-10) runs from east to west and connects San Bernardino County to Los Angeles County cities. It provides access to the areas surrounding downtown Los Angeles.
- The Pasadena Freeway (SR-110) runs from north to south and connects the San Gabriel Valley cities of Pasadena and South Pasadena to downtown Los Angeles and the Port of Los Angeles.
- The Glendale Freeway (SR-2) runs from north to south and connects downtown Los Angeles to the Foothill cities of Glendale, Montrose, and La Canada Flintridge.
- The Ventura Freeway (SR-134) runs from east to west and provides connection between the US-101 freeway and the I-210 freeway. It provides access to the neighboring cities of Glendale and Burbank.
- The North Hollywood Freeway (SR-170) runs from north to south and connects the SR-134 and I-5 freeways. It provides access to the cities of Panorama City, Pacoima, and other surrounding communities.
- The Ronald Reagan Freeway (SR-118) runs from east to west and connects Ventura County to the San Fernando Valley.
- The San Diego Freeway (I-405) runs from north to south and connects Orange County to Los Angeles County. I-405 terminates at this interchange providing access to cities in the San Fernando Valley.
- The Foothill Freeway (I-210) freeway starts at the I-5/I-210 interchange and provides connection between north Los Angeles County and the San Gabriel Valley.

According to 2008 traffic volumes from Caltrans (Exhibit 2-2), the I-5 North Corridor carries between 138,000 and 290,000 annual average daily traffic (AADT) depending on the location. The highest AADT occurs just north of the SR-170 junction at the Osborne Street interchange.

Exhibit 2-2: AADT and Truck Percentages on the I-5 North CSMP Corridor



Source: *AADT is from the Caltrans Traffic and Vehicle Data Systems Unit*

As indicated in Exhibit 2-3, the I-5 North CSMP Corridor is a Surface Transportation Assistance Act (STAA) route, which permits large trucks to operate on it. According to the 2008 Caltrans Annual Average Daily Truck Traffic data, verified truck counts comprise between 5.2 and 9.0 percent of the total daily traffic along the corridor with the highest percentage at the I-5/I-405 Junction. These percentages are high and indicate that the corridor is heavily used by trucks. There are truck lanes in both directions near this location, immediately north of the study corridor at the SR-14 split. They are about two and a half miles in length. These lanes separate trucks from mixed-flow traffic to enhance safety and/or stabilize traffic flow. The trucks that are traveling northbound are likely carrying transloaded cargo to other parts of the state.

Exhibit 2-3: Los Angeles County Truck Network on California State Highways

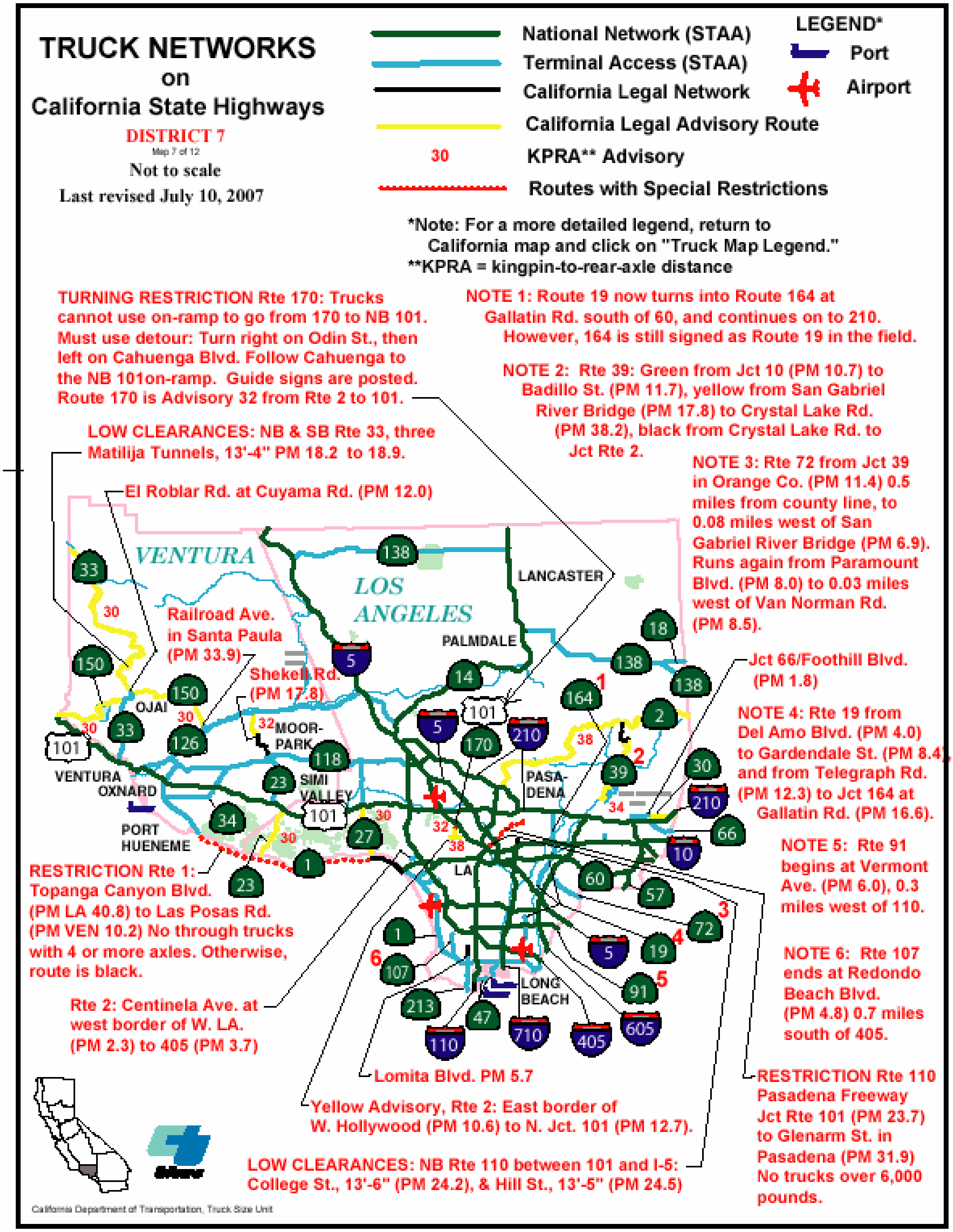
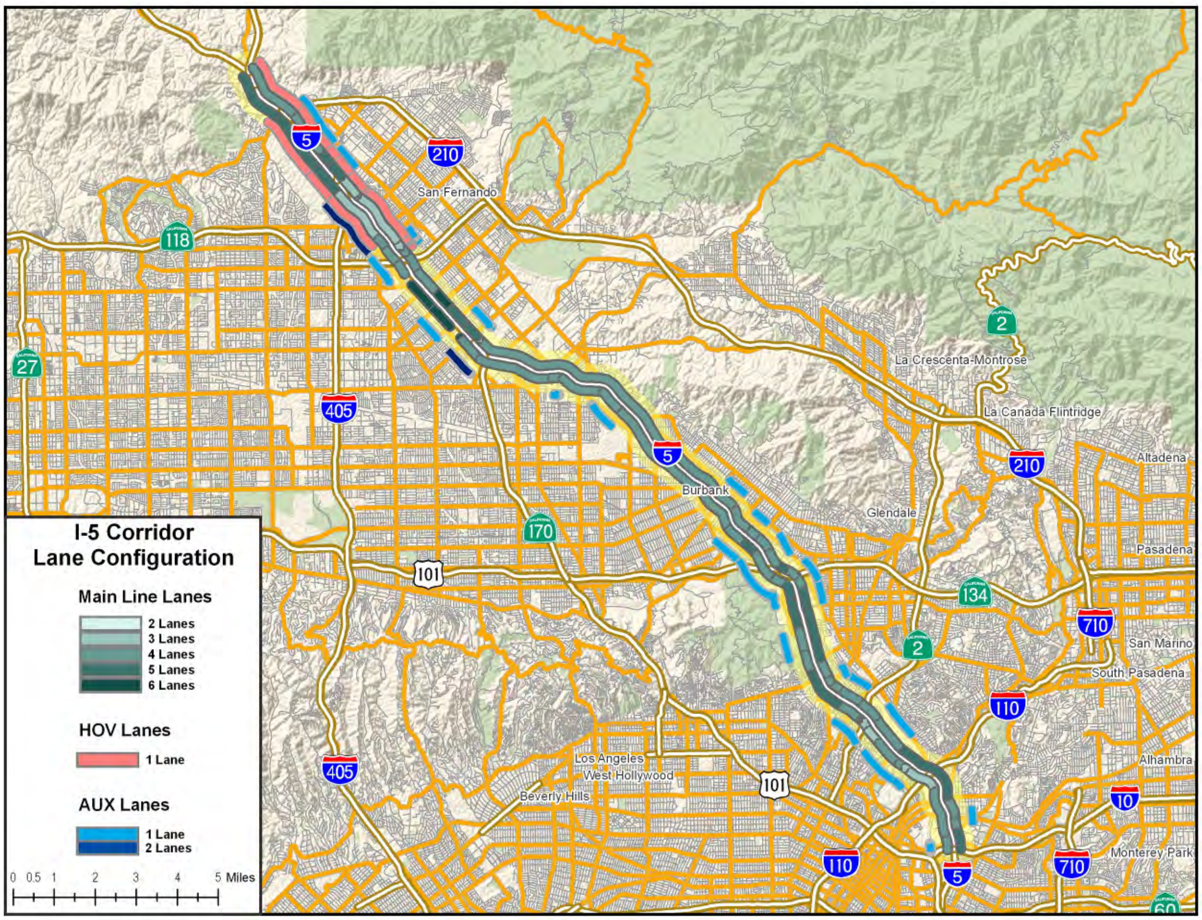


Exhibit 2-4 shows the lane configurations on the corridor according to the latest available aerial photos and field visit visits conducted. The current Transportation System Network (TSN) records and latest available aerial photos and photologs indicate that the I-5 generally has three to five lanes in each direction of travel. A concrete median barrier separates northbound and southbound traffic for most of the corridor. There are auxiliary lanes along many sections of the corridor with some only available on one side of the freeway. Currently, there is a six-mile stretch of HOV-lanes, one in each direction, from SR-118 to SR-14.

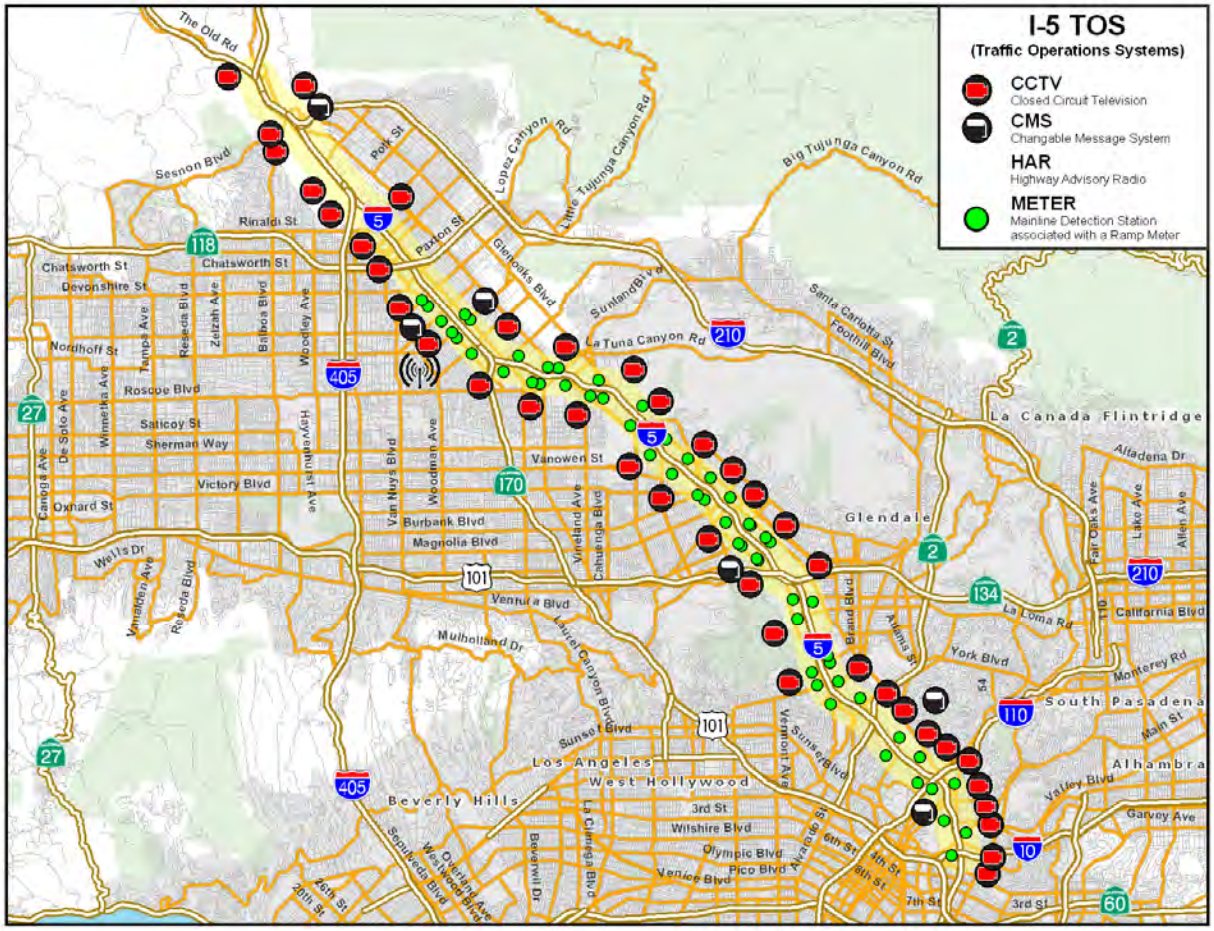
Exhibit 2-4: Lane Configuration on the I-5 North CSMP Corridor



Source: SMG mapping of field-verified lane configurations (April 2009)

The corridor also includes traffic operations and management systems, as shown in Exhibit 2-5. These include closed-circuit television (CCTV) cameras and fiber optic communications, changeable message signs (CMS), and vehicle detection stations.

Exhibit 2-5: Transportation Management Systems on the I-5 North CSMP Corridor



Recent Roadway Improvements

The first HOV lane on I-5 in Los Angeles County from the Simi Valley Freeway (SR-118) to the Antelope Valley Freeway (SR-14) opened in spring 2008. This project added 6.2 miles of HOV lane in each direction from SR-118 to SR-14. The HOV lane is currently being extended from SR-118 to SR-134 and is expected to be completed in 2011. The interchanges at Empire Avenue and Western Avenue are also being modified.

Caltrans began the I-5 Repavement Project in winter 2005. This project involves pavement grinding and the replacement of damaged concrete pavement on I-5 from the SR-60 to the cities of Glendale and Burbank. It also includes guardrail replacement work. The project is expected to be completed in winter 2010.

Corridor Transit Services

The following major public transportation operators provide service near the I-5 CSMP corridor:

- Southern California Regional Rail Authority (SCCRA) - Metrolink
- Amtrak
- Los Angeles County Metropolitan Transportation Authority (Metro)
- Santa Clarita Transit (SC)
- Antelope Valley Transit (AV)
- Los Angeles Department of Transportation (LADOT).

Metrolink operates the Antelope Valley Line, which runs parallel to the I-5 Corridor along San Fernando Road. It connects Lancaster to downtown Los Angeles and carries an average weekday ridership of 7,302. The Ventura County Line also operates along San Fernando Road from the SR-134 interchange connecting Ventura County to the downtown Los Angeles area with an average weekday ridership of 4,317. Exhibit 2-6 shows the Metrolink system map for Southern California.

Amtrak offers the Coast Starlight and Pacific Surfliner rail services that operate parallel to theI-5 North CSMP Corridor. The Coast Starlight offers daily service from Los Angeles to Oakland and Seattle. The Pacific Surfliner provides high-frequency service from San Diego to San Luis Obispo, via Los Angeles. The Pacific Surfliner is the second busiest corridor in the country with 2,898,859 riders in Fiscal Year (FY) 2008. According to the FY 2008 Amtrak Fact Sheet on the State of California, California has the highest Amtrak usage of any state in the country.

Metro services 1,433 square miles in Los Angeles County with over 190 bus lines and an average weekday passenger boarding of 1.2 million. Some of the Metro parallel bus routes include: Route 224 runs along Lankershim Boulevard; Routes 90, 91, 94, and 394 run along San Fernando Road; Route 230 runs along Laurel Canyon Boulevard; Route 292 runs along Glenoaks Boulevard; and Route 96 runs along Riverside Drive. Exhibit 2-7 shows Metro service in the vicinity of the I-5 North Corridor.

According to the Santa Clarita Transportation Development Plan 2006-2015, Santa Clarita Transit Express bus ridership was 314,000 for fiscal year 2005-2006. Express service frequency increased from 18 buses in 1996 to 28 buses in 2006. Several Santa Clarita Transit Express buses operate on the I-5 Corridor and provide access from the Santa Clarita Valley to the downtown Los Angeles area: SC784, SC788, SC794, and SC799.

Antelope Valley Transit Authority operates a fleet of 25 commuter coaches from Antelope Valley to Los Angeles and San Fernando Valley Monday through Friday.

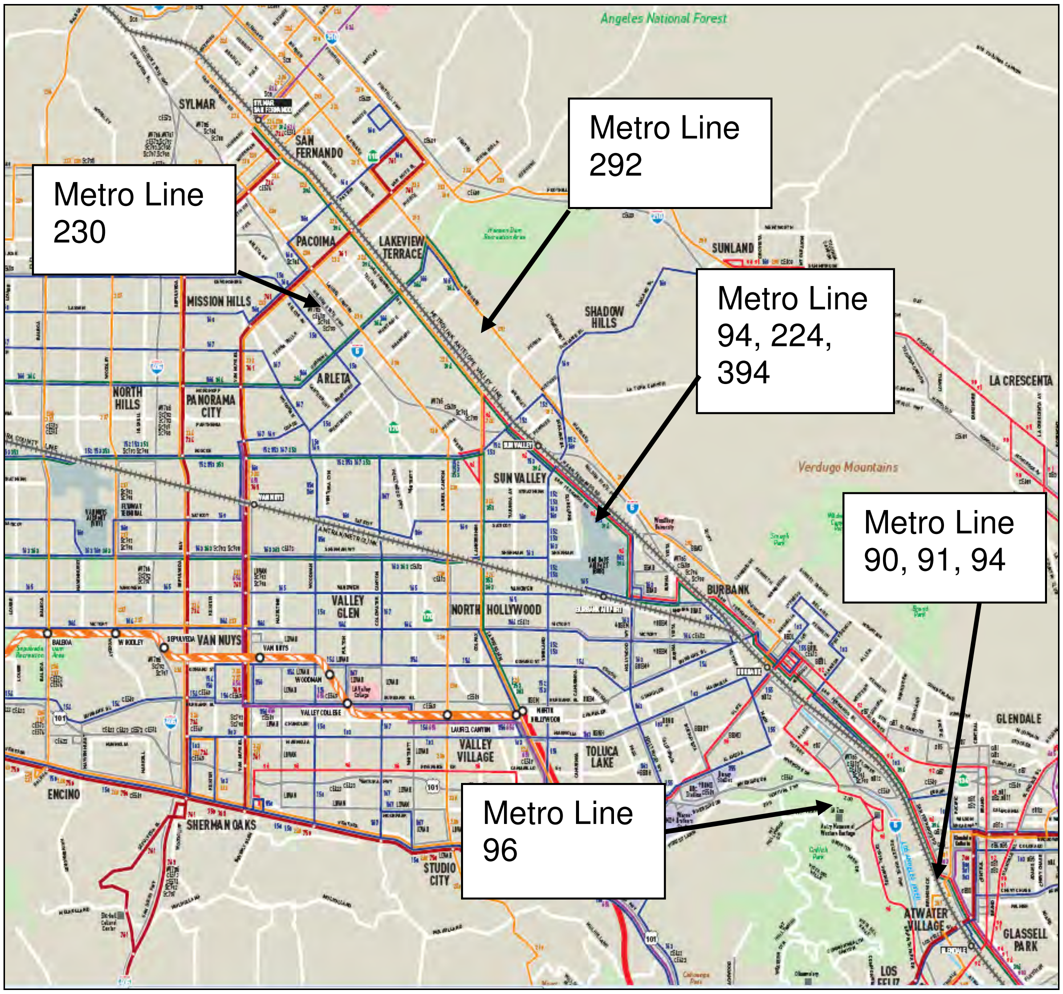
Ridership has tripled over the last decade of operation. Antelope Valley Transit currently operates AV785 and AV786 commuter coaches from the Antelope Valley to the San Fernando Valley and downtown Los Angeles area.

The City of Los Angeles Department of Transportation (LADOT) also operates Commuter Express (CE) buses that run on or adjacent to the I-5 Corridor. These routes include CE413 and CE419.

Exhibit 2-6: Metrolink System Map

Source: Metrolink

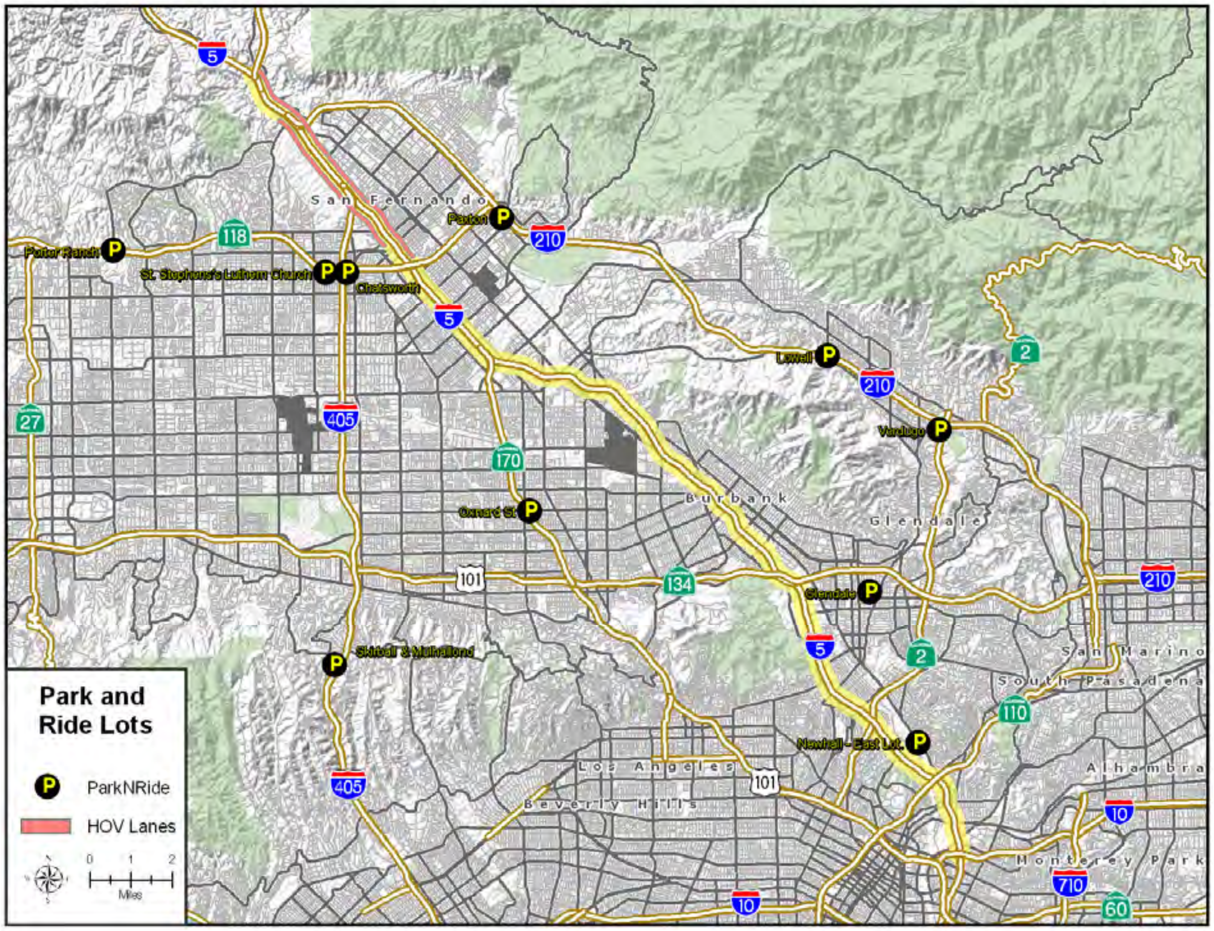
Exhibit 2-7: Metro Services Near the I-5 North CSMP Corridor



Source: Metro

There are several park and ride facilities near the study corridor, as illustrated in Exhibit 2-8. The parking lots which are closest to the corridor are at Newhall East, Glendale, Chatsworth and Paxton.

Exhibit 2-8: Park and Ride Facilities Near the I-5 North CSMP Corridor

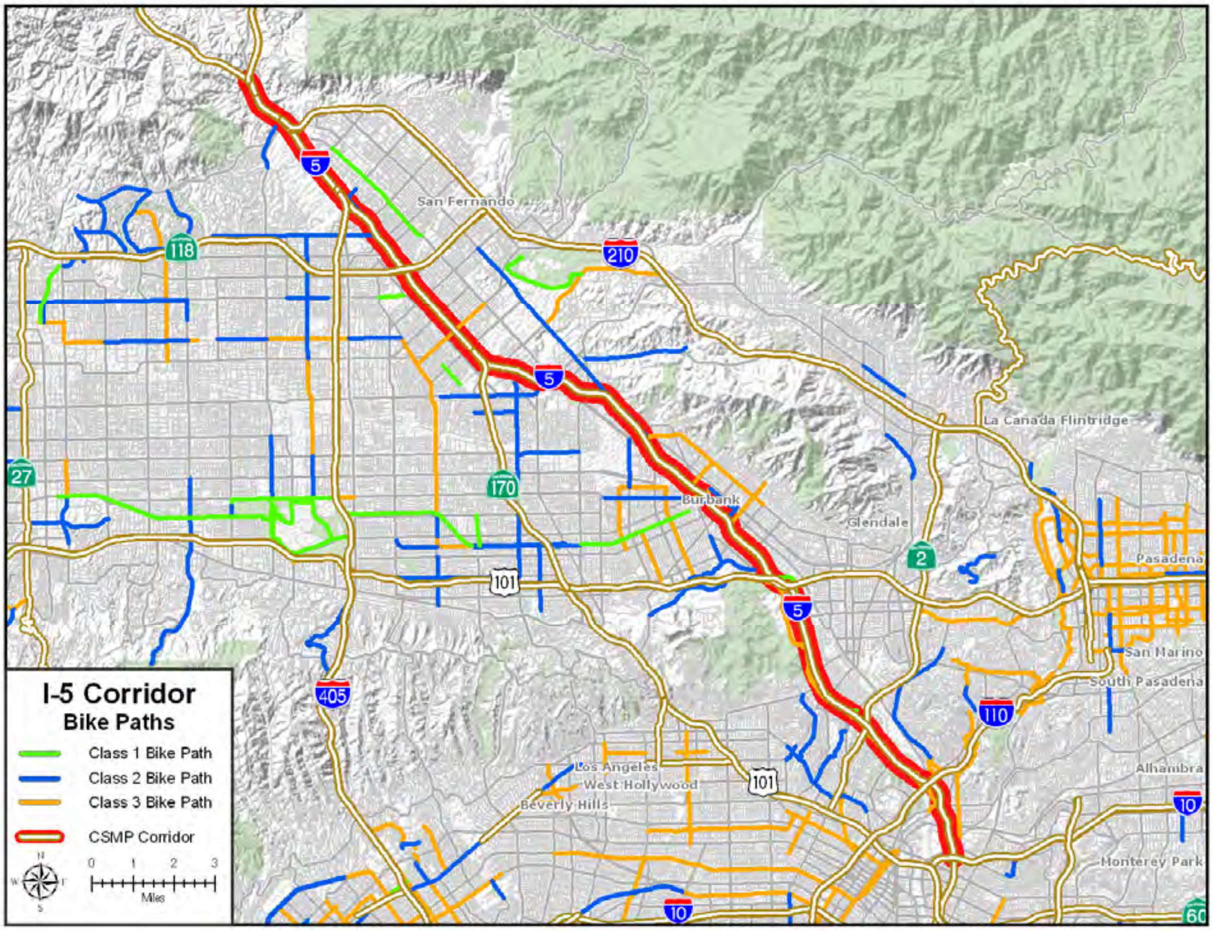


Bicycle Facilities

There are several bike paths near I-5. Two of these bike paths parallel the northern section of the study corridor and run along San Fernando Road and Glendale Boulevard. In the southern section of the corridor, there is a bike path that runs along the LA River. Exhibit 2-9 identifies the bike paths near the corridor and specifies the class of each path. There are three classes of bicycle facilities:

- Class I bike paths consist of a paved path within an exclusive right of way
- Class II bike lanes consist of signed and striped lanes within a street right of way,
- Class III bike routes are preferred routes on existing streets identified by signs only.

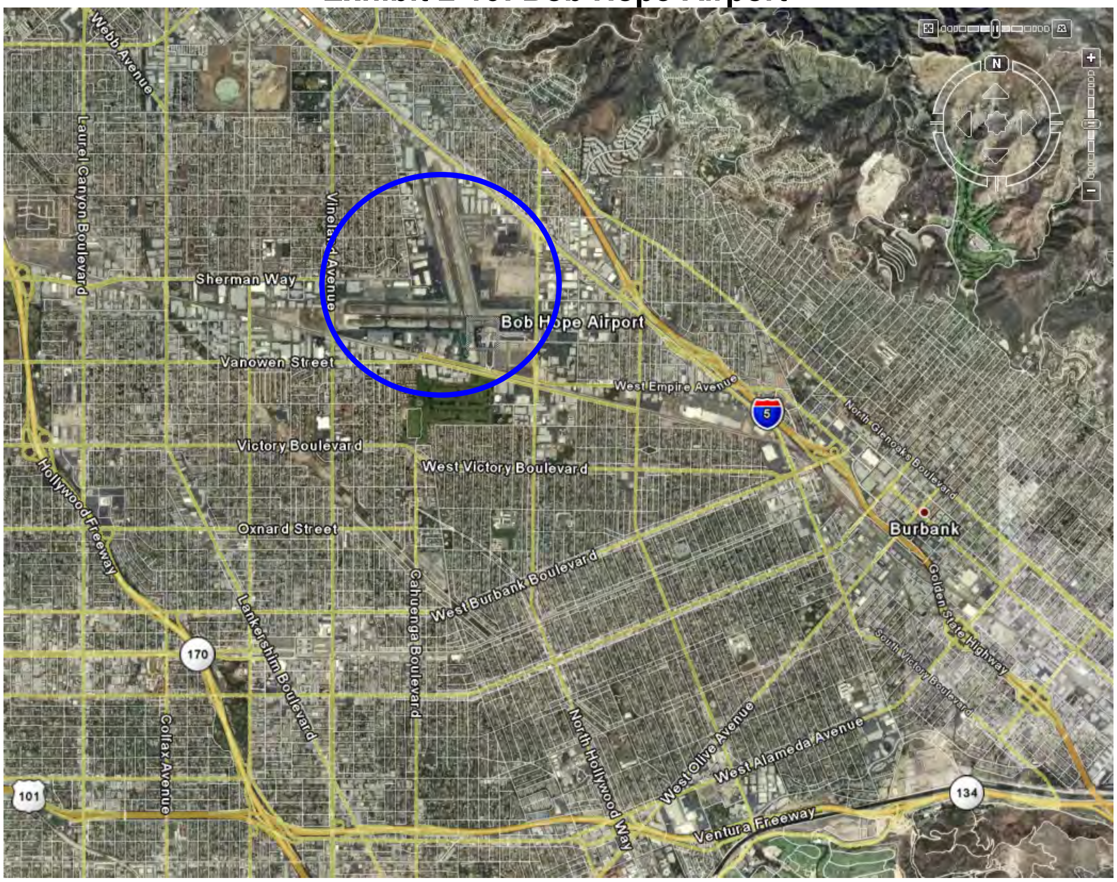
Exhibit 2-9: Bicycle Facilities Near the I-5 North CSMP Corridor



Intermodal Facilities

Bob Hope Airport is located in the City of Burbank and can be accessed by several freeways including I-5, SR-134, and SR-170. Exhibit 2-10 provides a satellite image of the facility and the surrounding area. Alaska, American, Delta, JetBlue, Skybus, Southwest, United, and US Airways operate out of Bob Hope Airport with frequent schedules along the West Coast as well as direct and connecting flights across the country. Other scheduled and charter or contract carriers include Federal Express, Champion Air Lines, Horizon Air, Mesa Airlines, United Parcel Service, AirNet Express, and Ameriflight. Total passengers deplaned and enplaned was 484,989 in September 2007, which reflects an increase of 4.9 percent from September 2006.

Exhibit 2-10: Bob Hope Airport



Source: Google Maps

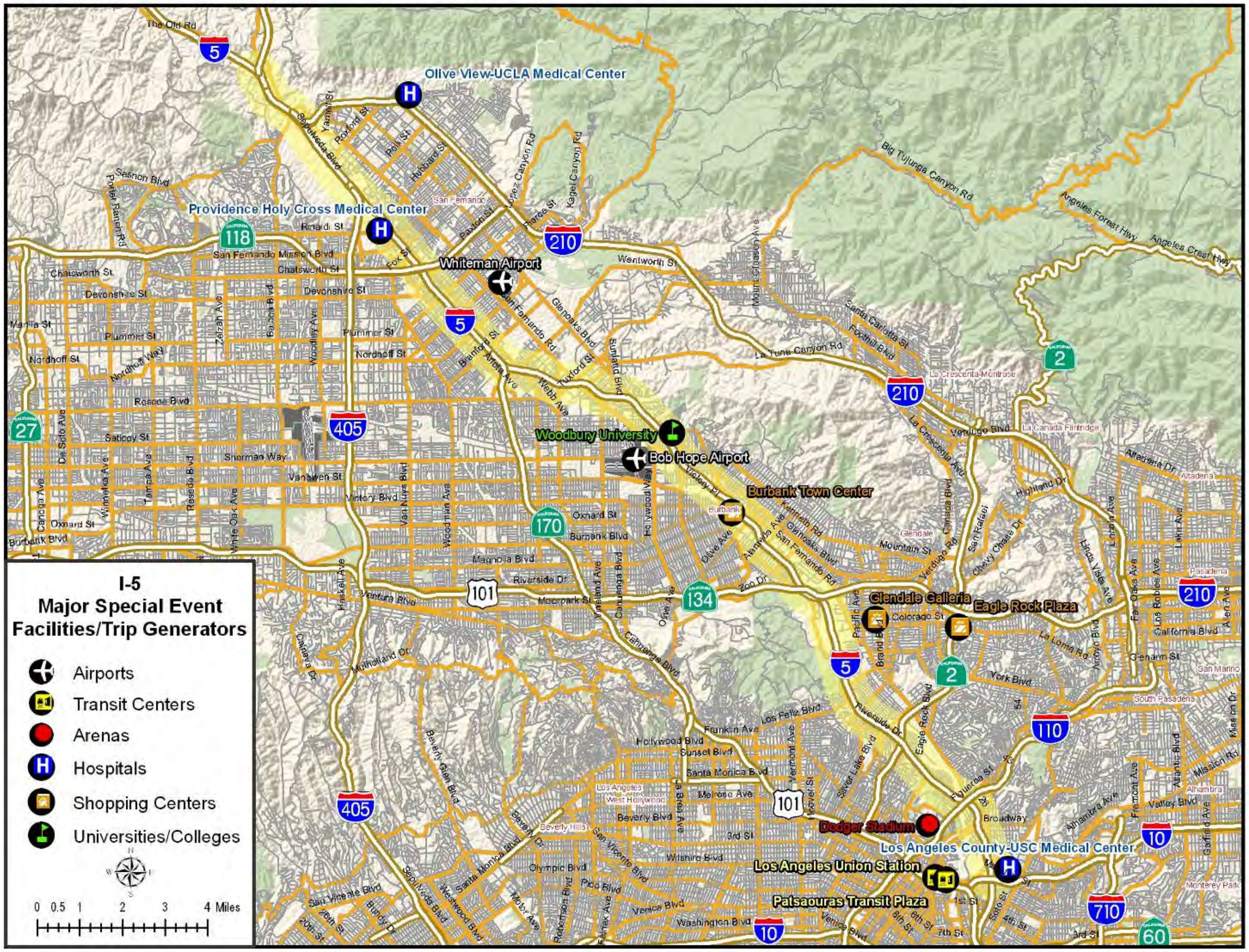
Whiteman Airport is located in the city of Pacoima off SR-118 in the San Fernando Valley, approximately one-mile east of I-5. No commercial airlines fly into this airport. Whiteman Airport is one of three weather monitoring sites for the National Weather Service in Los Angeles and is home to both Squadron 35 of the Civil Air Patrol and the Los Angeles County Fire Department Air Operations unit.

Special Event Facilities/Trip Generators

There are various facilities and institutions located along I-5 that may generate significant trips along the corridor. Exhibit 2-11 shows the location of the most significant traffic generators.

The I-5 Corridor serves Dodger Stadium, which is adjacent to downtown Los Angeles, and northwest of the I-5/SR-110 interchange. Dodger Stadium is the home of the Los Angeles Dodgers Major League Baseball team. The stadium has a seating capacity of approximately 56,000.

Exhibit 2-11: Major Special Event Facilities/Trip Generators



Source: *SMG mapping of trip generators*

The Staples Center is another sports arena in Downtown Los Angeles. It is home to several professional sports franchises - the NBA's Los Angeles Lakers and Los Angeles Clippers, the NHL's Los Angeles Kings and the WNBA's Los Angeles Sparks. The arena is host to 250 events and nearly 4,000,000 visitors a year. It can seat up to 20,000 patrons for concerts and roughly 18,000 for sporting events. Staples Center is located approximately four miles west of the I-5/I-10 Interchange.

Woodbury University is located in the City of Burbank, just east of the I-5. The University offers Bachelors degrees in arts and sciences and Masters degree in Business Administration with a total enrollment of approximately 1,500 students. There are also several elementary, middle, and high schools near the I-5 Corridor that could contribute to morning and afternoon traffic.

Three major medical facilities are located close to the corridor. Providence Holy Cross Medical Center is a 254-bed facility in Mission Hills. Located west of I-5 in the northern portion of the corridor, the facility provides treatment through its cancer centers, heart center, orthopedics, neurosciences and rehabilitation services, as well as women's and children's services. Olive View-UCLA Medical Center is a 377-bed teaching hospital located north of I-210 and three-miles east of the I-5. Los Angeles County-USC Medical Center is one of the largest teaching hospitals in the country. The Medical Center is affiliated with the Keck School of Medicine and is located one-mile west of the I-5 between the SR-110 and I-10 within close proximity to downtown Los Angeles. The Medical Center is staffed with more than 450 full-time faculty and approximately 850 medical residents, who serve over 50,000 inpatients and 750,000 outpatients annually.

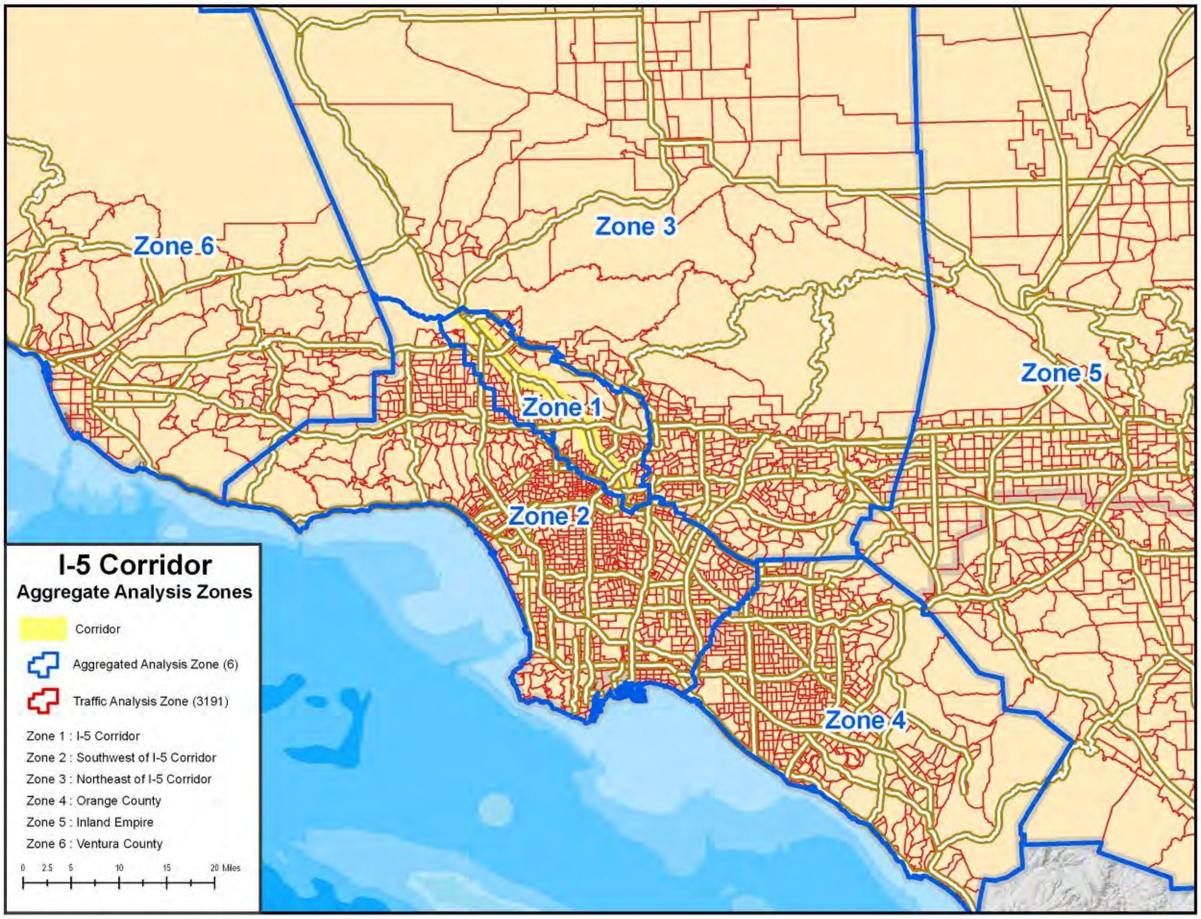
Other trip generators include Burbank Town Center, Glendale Galleria, The Americana, and Eagle Rock Plaza located within the southern portion of the I-5 Corridor.

In addition to the facilities listed above, Los Angeles Union Station, located in downtown Los Angeles approximately one mile west of the I-5, is the terminus for four long-distance Amtrak trains. Union Station serves as the hub for Metrolink’s passenger trains and provides connections to the Metro Red, Purple, and Gold light-rail lines. Patsaouras Transit Plaza is attached to Union Station. It provides many bus services including regular Metro and Metro Rapid bus lines, downtown DASH shuttles, FlyAway express service to Los Angeles World Airports, and several other municipal bus lines.

Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-5 North CSMP Corridor. Based on SCAG’s 2000 travel demand model, this “select link analysis” isolated theI-5 North CSMP Corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zone (TAZ), which were grouped into six aggregate analysis zones as shown in Exhibit 2-12. These zones were determined by county line and proximity to the corridor.

Exhibit 2-12: Aggregate Analysis Zones for I-5 North CSMP Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as shown on Exhibits 2-13 and 2-14 for the AM and PM peak periods. This analysis shows that a significant percentage of trips using the I-5 corridor represent inter-county trips. More than 60 percent of the trips either started or ended outside Los Angeles County.

During the AM peak period from 6:00 AM to 9:00 AM, about 39 percent of all trips originate and terminate in Los Angeles County (Zones 1, 2, and 3). The remaining trips originate in Los Angeles County and terminate in another county (23 percent), originate outside the Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (14 percent).

Exhibit 2-13: AM Peak Origin Destination by Aggregated Analysis Zone

		To Zone						
	AM Trips	I-5 North Corridor	Southwest of Corridor	Northeast of Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 North Corridor	6,113	13,846	4,260	189	5,033	7,707	553
	Southwest Corridor	12,065	30,426	10,035	819	13,437	14,901	1,831
	Northeast of Corridor	3,640	10,950	3,108	189	4,061	5,085	768
	Orange County	138	752	175	121	223	333	691
	Inland Empire	5,328	14,663	4,464	308	5,729	7,178	993
	Ventura County	7,755	17,555	5,643	349	6,703	8,873	553
	Outsize Zones	221	760	554	240	430	222	1,179

~ 39%	Trips starting and ending in Los Angeles County
~ 23%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 24%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 14%	Trips starting and ending outside of Los Angeles County

During the PM peak period from 3:00 to 7:00 PM (which experiences nearly 35 percent more demand than the AM peak period), the picture is similar. Roughly 38 percent of trips originate and terminate in Los Angeles County. The remaining trips originate in Los Angeles County and terminate in another county (23 percent), originate outside Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (15 percent).

Exhibit 2-14: PM Peak Origin Destination by Aggregated Analysis Zone

		To Zone						
	PM Trips	I-5 North Corridor	Southwest of Corridor	Northeast of Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 North Corridor	8,778	17,619	5,507	272	7,954	11,379	531
	Southwest Corridor	20,994	44,829	15,964	1,302	21,873	26,071	1,898
	Northeast of Corridor	6,423	15,262	4,782	259	6,658	8,816	778
	Orange County	329	1,392	323	212	482	585	784
	Inland Empire	7,762	19,958	6,187	456	8,645	10,475	971
	Ventura County	11,867	22,921	8,004	626	11,114	13,305	537
	Outsize Zones	1,306	4,066	2,054	1,554	2,245	1,250	2,233

~ 38%	Trips starting and ending in Los Angeles County
~ 24%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 23%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 15%	Trips starting and ending outside of Los Angeles County

3. CORRIDOR PERFORMANCE ASSESSMENT

This section summarizes the performance measures used to evaluate the existing conditions of the I-5 Corridor. The measures provide a technical basis to describe traffic performance on I-5 and were used to calibrate the micro-simulation model.

Before discussing the performance measures, this section describes the quality of the data used in the analysis. This was done to ensure that the automatic sensor data used for the analysis was sufficiently reliable.

Following the data quality discussion, four key performance areas are discussed in detail: mobility, reliability, safety, and productivity. The section also has information on the structural adequacy and ride quality of the pavement along the corridor.

A. Data Sources and Detection

The existing available data analyzed for the I-5 Corridor included the following sources:

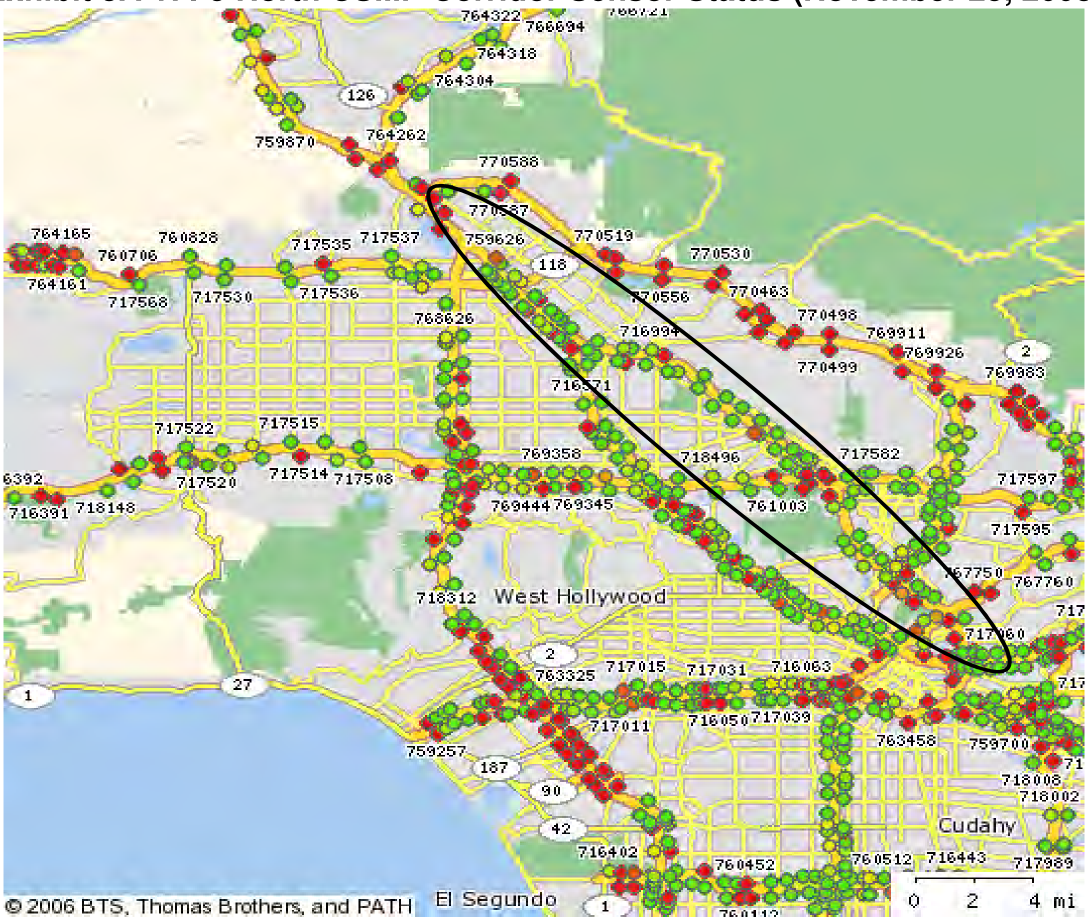
- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2004 – 2007)
- Caltrans Freeway Performance Measurement System (PeMS)
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Traffic study reports (various)
- Aerial photographs (Microsoft Virtual Earth and Google Earth) and Caltrans photologs
- Internet (i.e. Metro website, Metrolink website, etc.).

Numerous documents describe these data sources, so they are not discussed in detail in this report. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail below.

Freeway Detection Status

Exhibit 3A-1 depicts the corridor freeway facility with the detectors in place as of November 25, 2008. This date was chosen randomly to provide a snapshot of the detection status. The exhibit shows that there are many detectors on the mainline, almost all functioning well (based on the green color). Furthermore, it illustrates some seemingly small gaps between detectors at some locations.

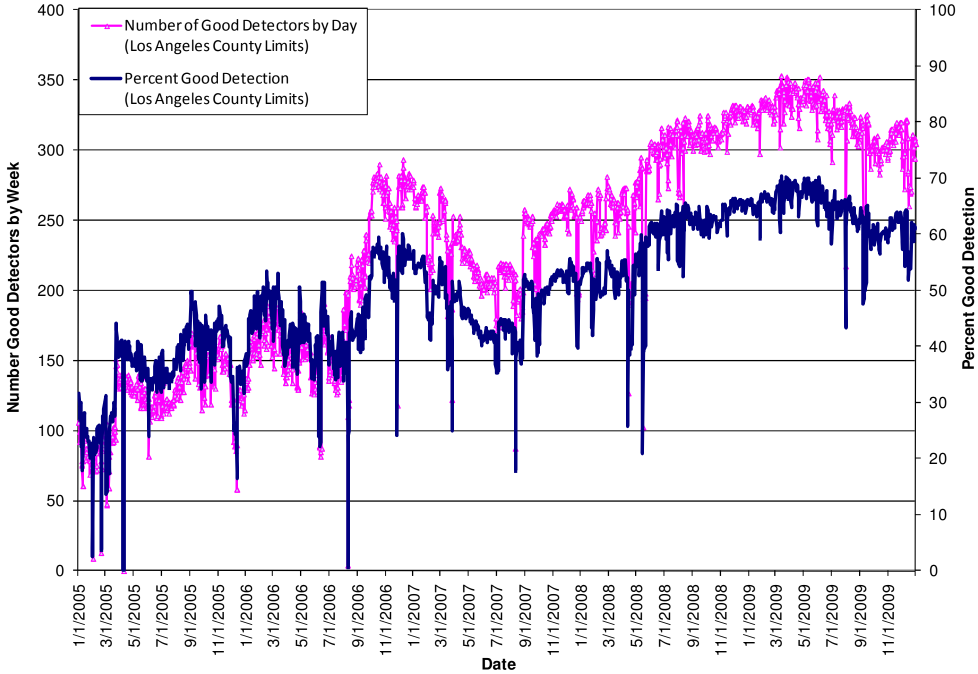
Exhibit 3A-1: I-5 North CSMP Corridor Sensor Status (November 25, 2008)



Source: Caltrans detector data

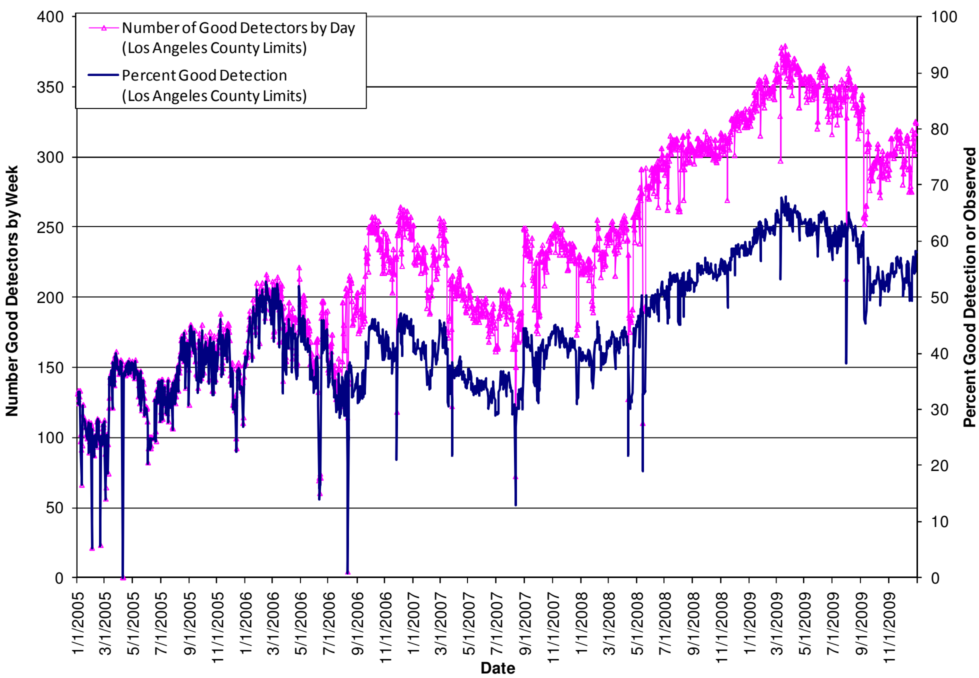
The following exhibits provide a better picture of how the detectors on the corridor performed over a longer period of time. Exhibits 3A-2 and 3A-3 report the number and percentage of "good" detectors by week for all of I-5 in Los Angeles County from 2005 to 2009. The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. These exhibits suggest that detection in the northbound direction (Exhibit 3A-2) was slightly better than the southbound direction (Exhibit 3A-3), particularly in 2007 and 2008 when the percentage of good detectors in the northbound direction reported around 50 to 60 percent compared to 40 to 50 percent in the southbound direction. In 2009, the number of detectors increased in both directions. However, the percentage of good detection for the southbound direction was around 55 percent compared to 60 percent for the northbound direction.

Exhibit 3A-2: Amount of Good Detection on Northbound I-5 (All Los Angeles County)



Source: Caltrans detector data

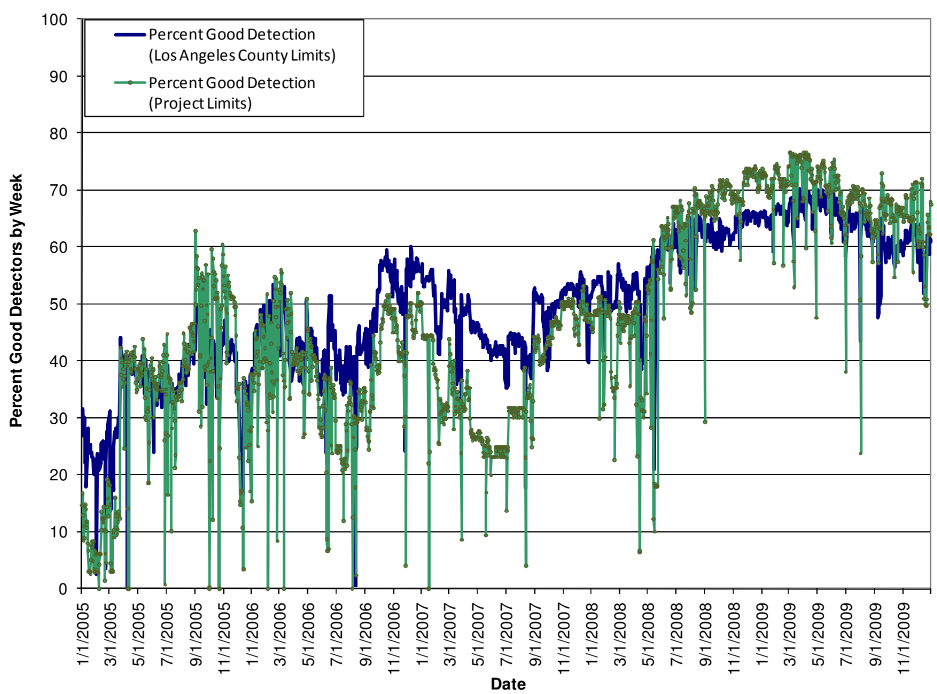
Exhibit 3A-3: Amount of Good Detection on Southbound I-5 (All Los Angeles County)



Source: Caltrans detector data

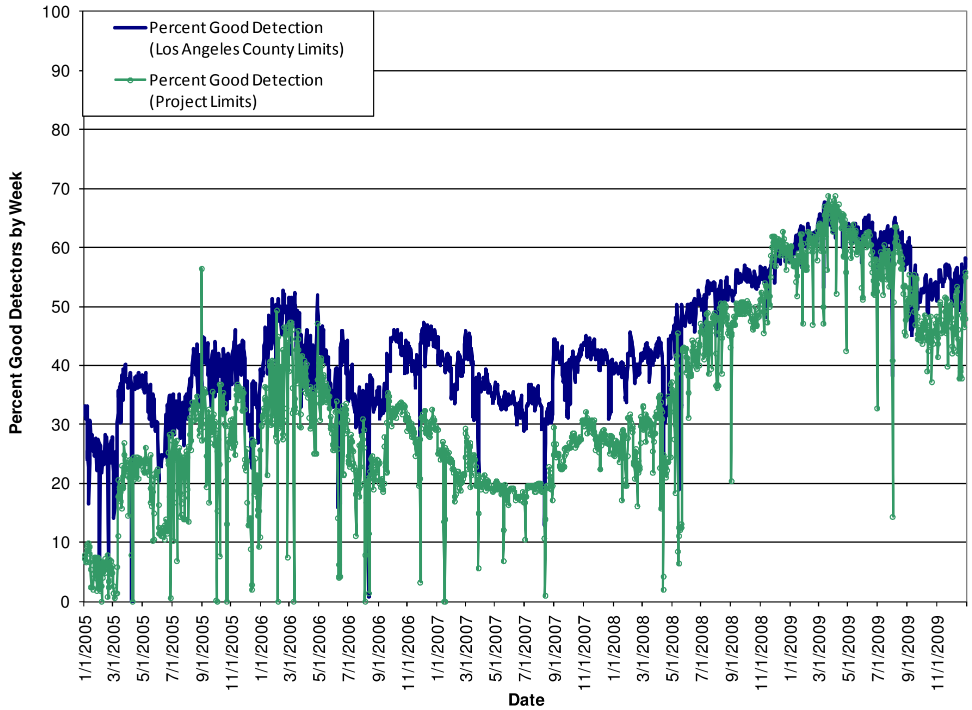
Exhibits 3A-4 and 3A-5 isolate the I-5 North Corridor (in green) and reports the percentage of good detectors within the I-5 corridor limits compared to all of LA County (in blue). As the exhibits illustrate, I-5 North CSMP Corridor appears to have better detection than the freeway as a whole (in LA County) in the northbound direction, while the opposite is true of the southbound direction. Similar to the countywide statistics reported in the previous exhibits, the northbound direction (Exhibit 3A-4) of the study corridor exhibited better detection compared to the southbound direction (Exhibit 3A-5). The detection on the study corridor generally improved between 2005 and 2009, reaching 75 percent in the northbound direction and 65 percent in the southbound direction.

Exhibit 3A-4: Amount of Good Detection on Northbound I-5 (I-5 North CSMP Corridor)



Source: Caltrans detector data

Exhibit 3A-5: Amount of Good Detection on Southbound I-5 (I-5 North CSMP Corridor)



Source: Caltrans detector data

Similar to the previous two exhibits detection improved significantly in 2008 and showed a slight drop by the end of 2009. Part of the increased detection quality in 2008 may be attributed to improved maintenance of the existing detection. Regardless of the reason, this trend is very encouraging and should allow for detailed analysis capabilities now and in the future. By comparing detectors in detail for theI-5 North CSMP Corridor, the study team identified several detectors that were added to the corridor 2008. These are shown in Exhibit 3A-6.

Exhibit 3A-6: I-5 Detection Added as of 2009

VDS	Location	Type	CA PM	Abs PM	Date Online
NORTHBOUND					
771135	Rte 118CN	HOV	39.51	156.143	9/11/2008
771143	San Fernando 1	HOV	40.17	156.803	9/11/2008
771155	Roxford	HOV	42.75	159.383	9/11/2008
771157	N of 210	HOV	R44.32	160.73	9/11/2008
771150	Laurel Canyon	HOV	40.44	157.073	9/11/2008
771160	WB 210 To NB TRK RTE	Fwy-Fwy	44.321	160.731	9/11/2008
768700	WB 210 To NB 5	Fwy-Fwy	44.322	160.732	9/11/2008
771158	NB 5 Truck Route	Fwy-Fwy	R44.32	160.73	9/11/2008
SOUTHBOUND					
771136	Rte 118 CN to Paxton	Off-Ramp	39.51	156.08	9/11/2008
771147	San Fernando 2	HOV	40.31	156.88	9/11/2008
771148	San Fernando 2	Off-Ramp	40.31	156.88	9/11/2008
771153	Roxford	HOV	42.42	158.99	9/11/2008

Source: *Caltrans detector data*

Finally, an analysis of gaps without detection is shown in Exhibit 3A-7. There are several segments extending over 0.75 miles without detection in each direction. These should be considered for deployment of additional detection when funding becomes available.

Exhibit 3A-7: I-5 Gaps In Detection (November 25, 2009)

Location		Abs PM		Length (Miles)
From	To	From	To	
NORTHBOUND				
MARENGO	PASADENA	135.34	136.63	1.29
PASADENA	RIVERSIDE	136.63	137.73	1.10
LOS FELIZ 2	COLORADO	141.17	142.53	1.36
COLORADO	N OF 134	142.53	143.51	0.98
ALAMEDA 2	OLIVE	145.08	145.90	0.82
BUENA VISTA	HOLLYWOOD WAY	148.04	149.04	1.00
HOLLYWOOD WAY	SUNLAND	149.04	150.35	1.31
LANKERSHIM	SHELDON	151.70	152.47	0.77
SHELDON	BRANFORD 2	152.47	153.55	1.08
VAN NUYS 2	PAXTON	155.18	155.94	0.76
LAUREL CANYON	ROXFORD	157.07	159.38	2.31
ROXFORD	N OF 210	159.38	160.73	1.35
N OF 210	RTE 14 CN -TRUCK RTE	160.73	162.01	1.28
RTE 14 CN -TRUCK RTE	WELDON CANYON	162.01	163.18	1.17
SOUTHBOUND				
BROADWAY	AVE 26	136.02	136.90	0.88
DUVALL	DORRIS	137.27	138.04	0.77
N OF 2	GLENDALE	139.33	140.15	0.82
GRIFFITH PARK	COLORADO	141.11	142.42	1.31
ZOO DR	VICTORY TR	142.92	143.77	0.85
VERDUGO	BURBANK 1	145.47	146.25	0.78
BURBANK 2	LINCOLN	146.46	147.26	0.80
BUENA VISTA	HOLLYWOOD WAY	147.99	148.85	0.86
HOLLYWOOD WAY	ROSCOE	148.85	149.80	0.95
LANKERSHIM	SHELDON	151.64	152.41	0.77
SHELDON	BRANFORD 1	152.41	153.32	0.91
SAN FERNANDO 2	ROXFORD	156.88	158.99	2.11
ROXFORD	S OF 210	158.99	159.96	0.97
S OF 210	RTE 14 CN -TRUCK RTE	161.95	162.92	0.97
WELDON CANYON	CALGROVE	162.92	165.15	2.23

Source: *Caltrans detector data*

B. Corridor Performance Assessment

The I-5 North CSMP focuses on four categories of performance measures:

- *Mobility* describes how quickly people and freight move along the corridor.
- *Reliability* captures the relative predictability of travel time along the corridor.
- *Safety* provides an overview of collisions along the corridor.
- *Productivity* quantifies the degree to which traffic inefficiencies at bottlenecks or hot spots reduce flow rates along the corridor.

MOBILITY

Mobility describes how well the corridor moves people and freight. The mobility performance measures are both readily measurable and straightforward for documenting current conditions and are readily forecasted making them useful for future comparisons. Two primary measures are typically used to quantify mobility: delay and travel time.

Delay

Delay is defined as the total observed travel time less the travel time under non-congested conditions, and is reported as vehicle-hours of delay. Delay can be computed for severe congested conditions using the following formula:

$$(\textit{Vehicles Affected per Hour}) \times (\textit{Dis}\tan \textit{ce}) \times (\textit{Duration}) \times \left[\frac{1}{(\textit{Congested Speed})} - \frac{1}{35mph} \right]$$

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2,000 vehicles per hour per lane), while others use a measured or estimated flow rate. The distance is the length under which the congested speed prevails and the duration is the hours of congestion experience below the threshold speed.

The threshold speed can also vary. In general, the threshold speed represents free-flow or some other pre-defined speed. In this CSMP analysis, 60 mph is considered free-flow speed for the corridor, and will be used to calculate delay.

Different reports and studies use other threshold speeds, typically 35 mph (e.g., HICOMP), which is defined here as the “severe congestion” speed threshold, and 45 mph (Federal Highway Administration threshold to define HOV degradation).

The HICOMP annual report discussed in the following section uses the 35 mph threshold speed and assumes 2,000 vehicles per hour per lane as the throughput threshold. HICOMP therefore reports on severe delay, while the automatic detector data uses 60 mph and the reported number of vehicles reported by the detectors. Each of these two sources is discussed separately since their results are extremely difficult to compare because of methodological and data collection differences.

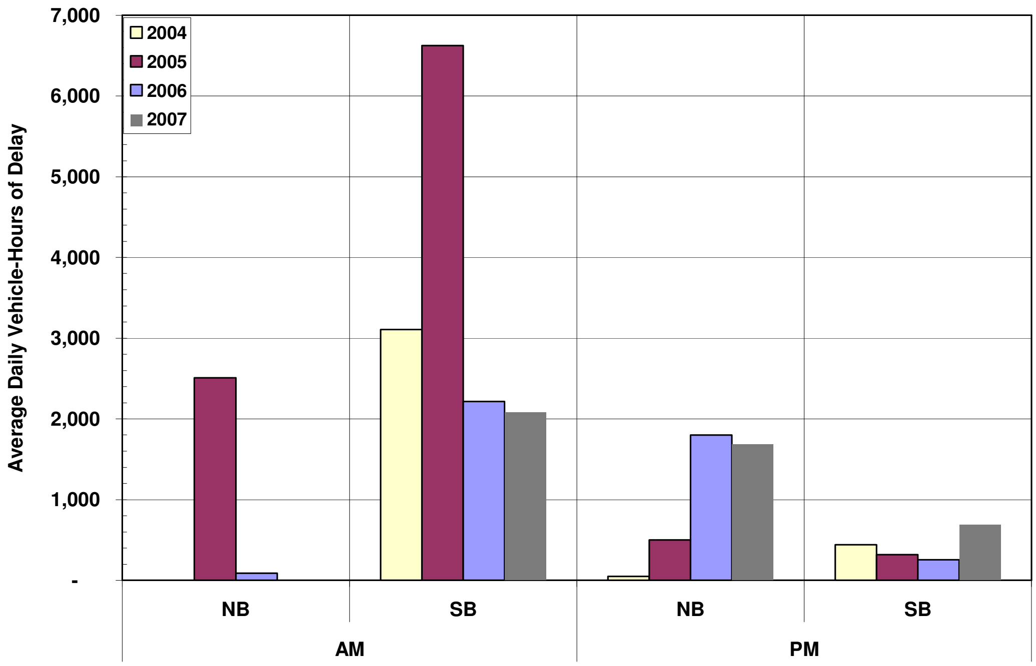
Caltrans HICOMP

The Caltrans Highway Congestion Monitoring Program (HICOMP) report has been published annually by Caltrans since 1987. Delay is presented as average daily vehicle-hours of delay (DVHD). The HICOMP defines delay as travel time in excess of free flow travel time when speeds dip below 35 mph for 15 minutes or longer.

For the HICOMP report, probe vehicle runs are performed only one to four days during the entire year for the mainline facility only. Ideally, two days of data collection in the spring and two in the fall of the year are desired, but resource constraints may affect the number of runs performed during a given year. As will be discussed later in this section when discussing the automatic detector data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, and special events, the price of gasoline, and construction activities.

Exhibit 3B-1 shows yearly delay from 2004 through 2007 for the two peak periods of the I-5 Corridor in both directions. The southbound direction generally experienced the most congestion during the AM peak period, while the northbound direction experienced the most delay during the PM peak.

Exhibit 3B-1: HICOMP Average Daily Vehicle-Hours of Delay (2004-2007)



Source: 2004-2007 HICOMP Report

Exhibit 3B-2 lists all of the congested segments shown in the last four HICOMP reports for the I-5 North Corridor. As the exhibit illustrates, the lengths of the congested segments vary from one year to the next.

Exhibit 3B-2: HICOMP Congested Segments (2004-2007)

Period	Dir	PM From/To	Generalized Congested Area	Generalized Area Congested Average Vehicle-Hours of Delay			
				2004	2005	2006	2007
AM	NB	18.0/22.5	Brooklyn Ave to SR-2		2,029		
		20.4/21.9	Avenue 26 to Riverside Dr/Eads			88	
		33.5/38.5	Sunland Bl to Van Nuys Bl		479		
	SB	40.0/32.5	Brand Bl to Hollywood Wy		921		
		40.0/24.0	Brand Bl to LA River Bridge/SR-134 Sep	1,093			
		37.9/34.9	Terra Bella St to Lankershim Bl			79	
		30.0/21.0	Burbank Bl to Elmgrove St		5,426		
		29.4/26.9	Magnolia Ave to SR-134			63	
		28.4/24.93	Alameda Ave to Cold Spring Dr				427
		27.0/17.0	LA River Bridge/SR-134 Sep to EB SR-60	2,013			
		26.4/21.4	SR-134 to SR-110/Riverside Dr			1,635	
		24.9/20.9	Cold Spring Dr to SR-110/Riverside Dr				1,635
		20.9/16.4	Duvall St to SR-60			438	
		20.0/17.0	Pasadena Ave to SR-60		278		
		19.9/17.9	SR-110 to I-10				24
AM PEAK PERIOD SUMMARY				3,106	9,133	2,305	2,086
PM	NB	16.9/19.4	7th St to n/o Main St				362
		17.9/21.9	Brooklyn Ave to Riverside Dr/Eads			431	
		19.0/22.5	Alhambra Ave to SR-2		212		
		24.9/26.9	n/o Los Feliz Rd to SR-134				258
		26.5/30.0	SR-130 Junction to Burbank Bl	47			
		26.9/28.9	Magnolia Ave to Verdugo Ave			649	566
		27.5/29.0	Sonora Ave to Olive Ave		49		
		31.9/34.9	s/o North Hollywood Way to Penrose St				282
		33.4/36.9	Roscoe Bl to Branford St			515	
		33.5/36.5	Sunland Bl to SR-170		178		
		34.4/36.9	Penrose St to Branford St				78
		36.5/38.5	SR-170 to Van Nuys Bl		57		
		36.9/38.9	Branford St to s/o Paxton St				140
		36.9/39.4	Branford St to Laurel Canyon Bl			204	
	SB	34.5/32.5	Penrose St to Hollywood Wy		116		
		32.9/29.4	s/o Sunland Blvd to Magnolia Ave				145
		30.5/27.0	San Fernando Bl to LA River Bridge/SR-134 Sep	440			
		30.0/26.5	Burbank Bl to SR-134		116		
		29.4/26.9	Magnolia Ave to SR-134			65	
		28.9/26.4	Verdugo Ave to SR-134				209
		26.4/22.4	SR-134 to SR-2				286
		25.4/22.4	Edenhurst to SR-2			188	
		23.5/21.5	Glendale Bl to Riverside Dr		85		
		19.9/17.9	Pasadena Ave To Cesar E Chavez Ave				51
PM PEAK PERIOD SUMMARY				487	815	2,052	2,377
TOTAL CORRIDOR CONGESTION				3,593	9,948	4,357	4,463

According to Exhibit 3B-2, the most significant delay occurred in 2005 during the AM peak period in the southbound direction from Burbank Boulevard to Elmgrove Street. This segment falls within the project limits for both of the Caltrans construction projects that started in 2005. Traffic on the northbound segment between Brooklyn Avenue and SR-2 also experienced heavy delays in 2005. Total delay for the corridor decreased by over 55 percent from 2005 to 2006, and increased slightly from 2006 to 2007 by about 2.5 percent.

While delay during the PM peak period grew from year to year, Exhibit 3B-2 shows that the variation in delay during the PM was not as significant as the AM peak period, which experienced a 75 percent decline in delay between 2005 and 2006. The higher than normal delay in 2005 is likely attributed to night-time construction that would have left the PM peak unaffected. Morning commute traffic may have experienced residual delay after traffic lanes opened from the previous night's activities. Detector data quality was lower in the first half of 2005 and may be another factor affecting the results.

Exhibits 3B-3 and 3B-4 present the congestion information in map form for the AM and PM peak commute periods in 2007. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown. More "generalized" congested segments were created so that segment comparisons can be made from one year to the next.

Exhibit 3B-3: HICOMP Congested Segments Map - AM Peak Period (2007)

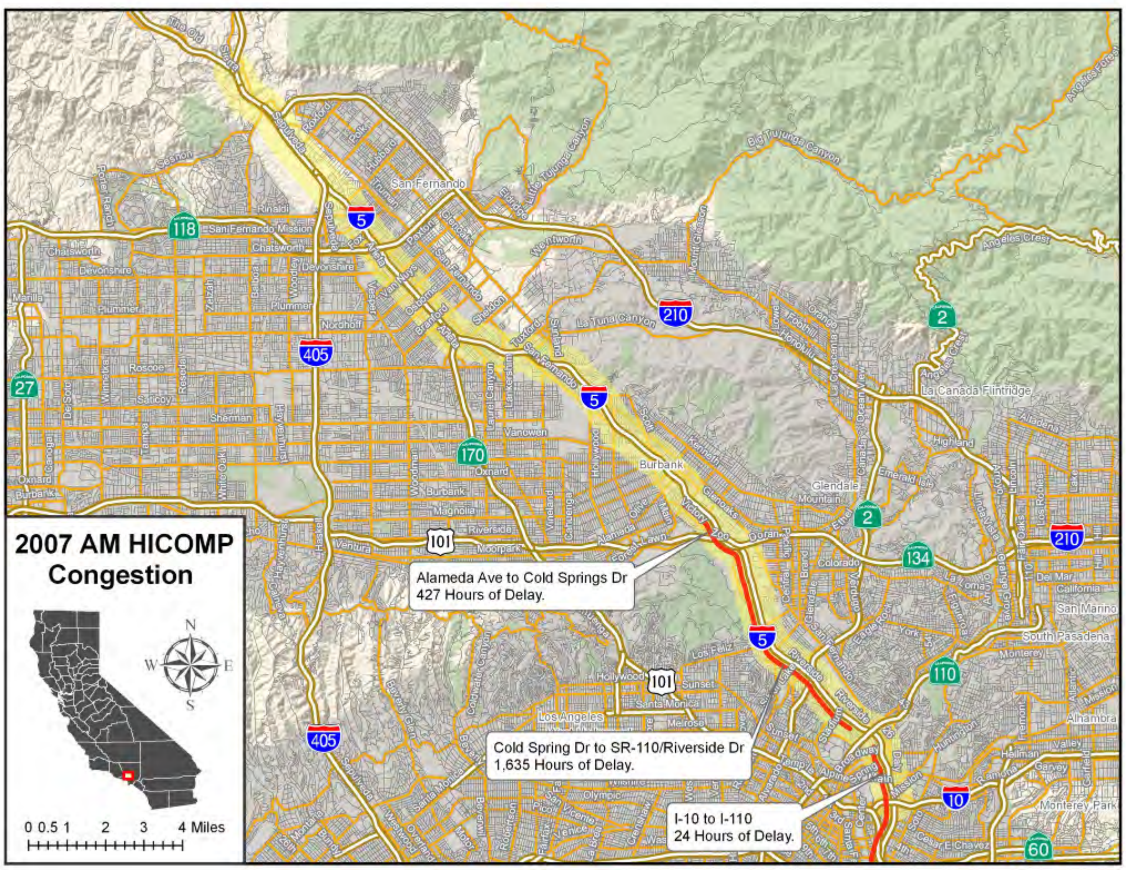
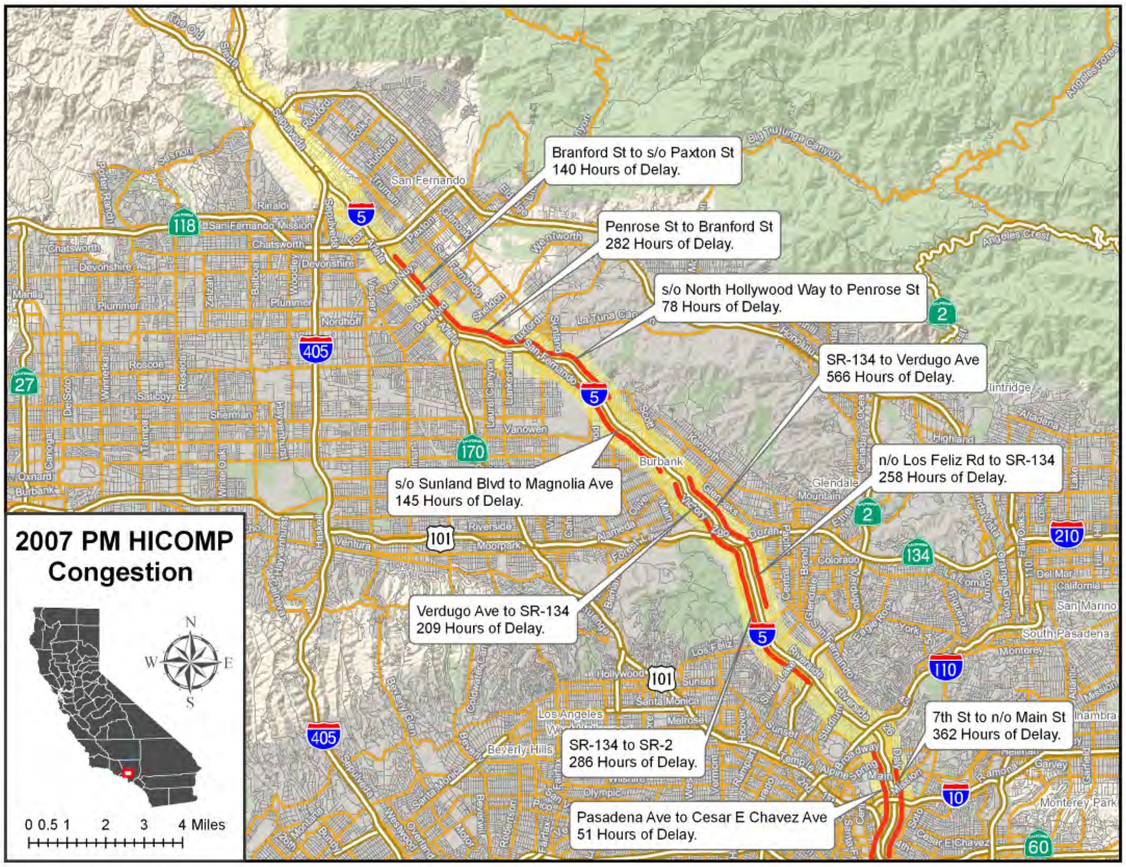


Exhibit 3B-4: HICOMP Congested Segments Map - PM Peak Period (2007)



Automatic Detector Data

Using freeways detector data, delay is computed for every day and summarized in different ways, which is not possible when using probe vehicle data.

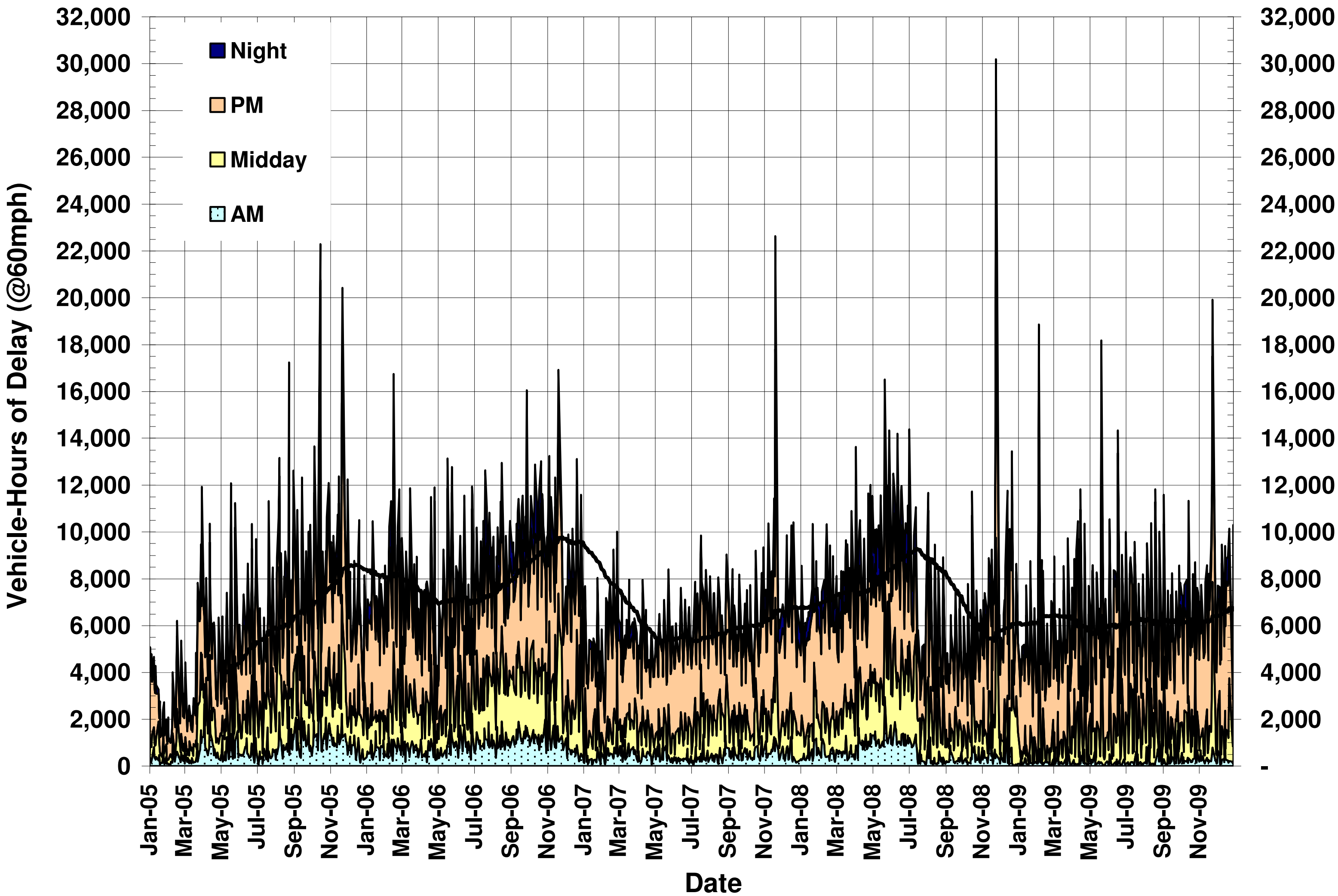
Performance assessments were initially conducted for the three-year period between 2005 and 2007. These assessments were recently updated through December 2009. The performance assessment includes five years of automatic detector data. Unlike HICOMP where delay is only considered and captured for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delay presented in this section represent the difference in travel time between actual conditions and free-flow conditions at 60 miles per hour, applied to the actual output flow volume collected from a vehicle detector station.

Exhibits 3B-5 and 3B-6 show the five-year trend in weekday (i.e., excluding weekends and holidays) delay for the entire corridor in the northbound and southbound directions respectively. The exhibits also show a 90-day moving average that reduces the day-to-day variations and more easily illustrates the seasonal and annual changes in congestion over time.

As indicated in Exhibit 3B-5, the majority of delay in the northbound direction occurred during the PM peak period. Daily delay grew between 2005 and 2006, declined in 2007, gradually increased during the first half of 2008, but sharply declined in the summer of 2008 with variation in delay from one day to the next. Daily delay was lower in 2007 than in 2006 and more consistent from one day to the next, with the exception of a high-delay incident in the last quarter of 2007. In 2008, daily delay increased steadily until July when delay sharply declined through 2009.

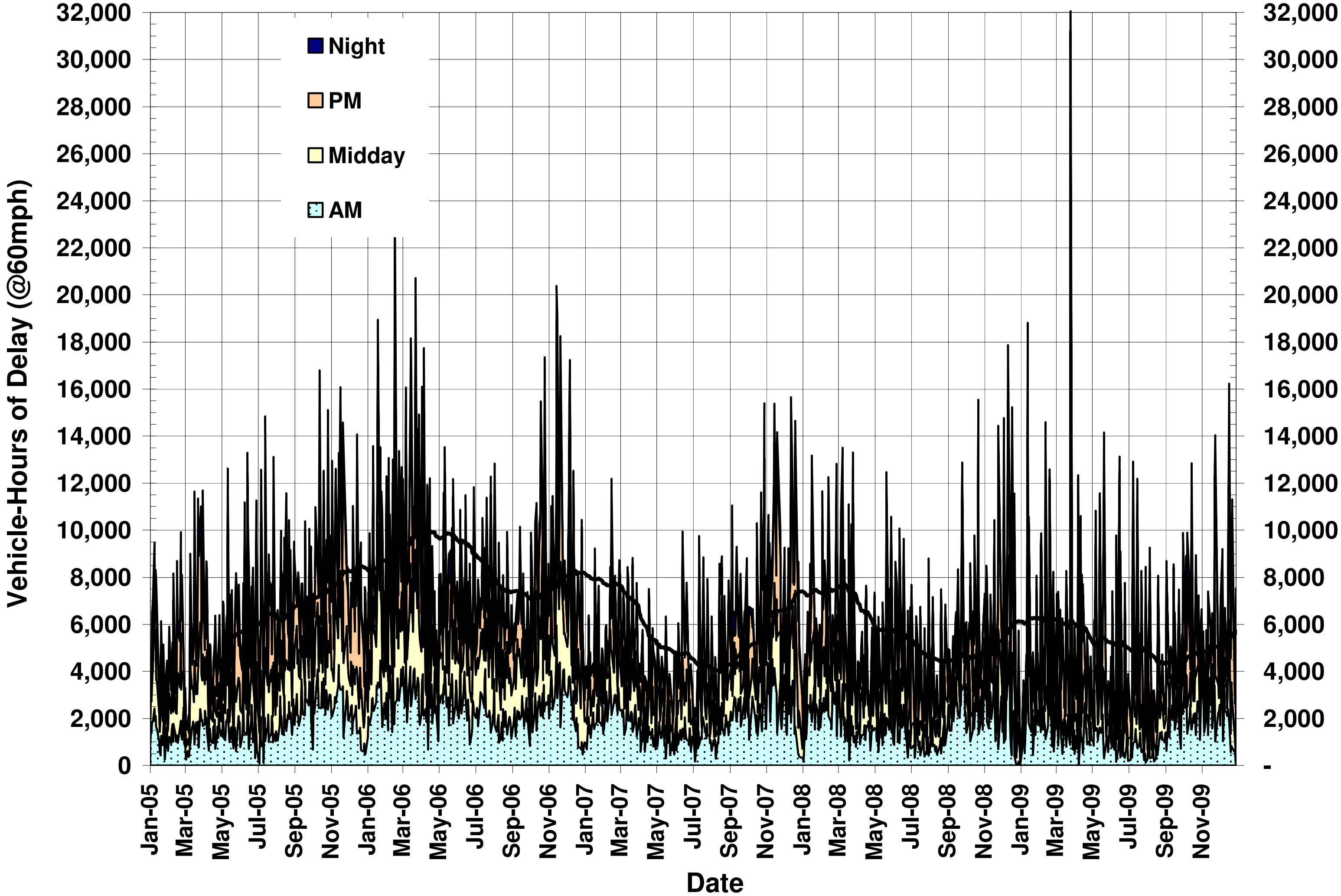
Trends for the southbound direction differ from those for the northbound direction, reflecting the directional commute patterns toward downtown Los Angeles. As shown in Exhibit 3B-6, the majority of delay in the southbound direction occurred during the AM peak period rather than the PM peak period. Like the northbound direction, the southbound direction experienced increases in daily delay during 2005 and the first quarter of 2006. Unlike the northbound direction, southbound daily delay started declining during the second quarter of 2006. The decline in the second quarter of 2006 continued through August 2007, when the trend reversed and daily delay started to increase until spring 2008. Delay in 2009 was slightly lower than the delay experienced in 2008.

Exhibit 3B-5: Northbound I-5 Average Daily Delay by Time Period (2005-2009)



Source: Caltrans detector data

Exhibit 3B-6: Southbound I-5 Average Daily Delay by Time Period (2005-2009)



Source: Caltrans detector data

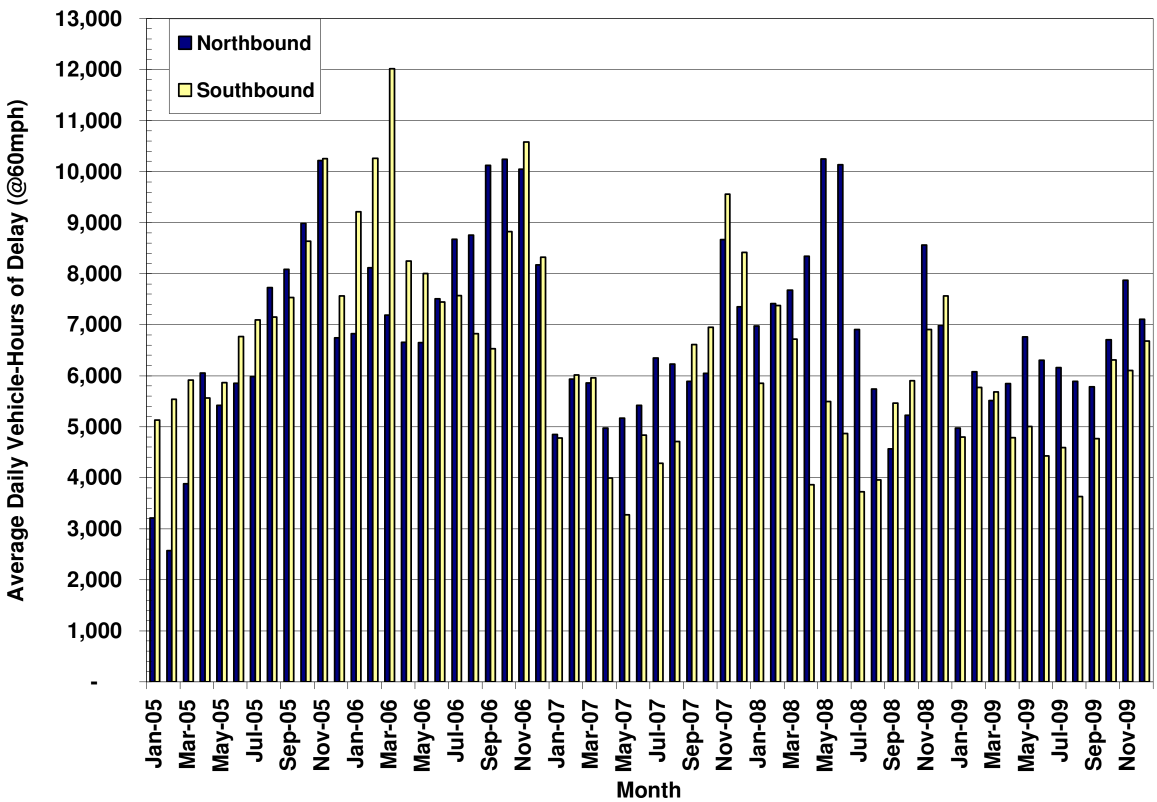
Exhibit 3B-7 shows the average weekday daily vehicle-hours of delay for each month between 2005 and 2009 for the I-5 North Corridor. These figures exclude weekends and holidays. This exhibit reveals the following delay trends:

- Congestion on the corridor increased from 2005 to 2006, which was probably due to economic growth in the region and the country. In 2007, however, delay decreased and leveled off, most likely due to the global financial meltdown and the associated recession. As of the end of 2009, congestion levels had still not reached 2006 levels.

- Delay was lower during the summer months and was highest in the year 2006.

- In the northbound direction, delay increased steadily from November 2007 to June 2008. However during the same period, the southbound direction experienced a gradual decline in delay. In 2009, the delay in both directions is lower than all the other years.

Exhibit 3B-7: I-5 Average Weekday Delay by Month (2005-2009)



Source: Caltrans detector data

Delays presented to this point represent the difference in travel time between "actual" conditions and free-flow conditions at 60 miles per hour. This delay can be segmented into two components as shown in Exhibit 3B-8:

- Severe delay – delay occurring when speeds are below 35 miles per hour
- Other delay – delay occurring when speeds are between 35 and 60 miles per hour.

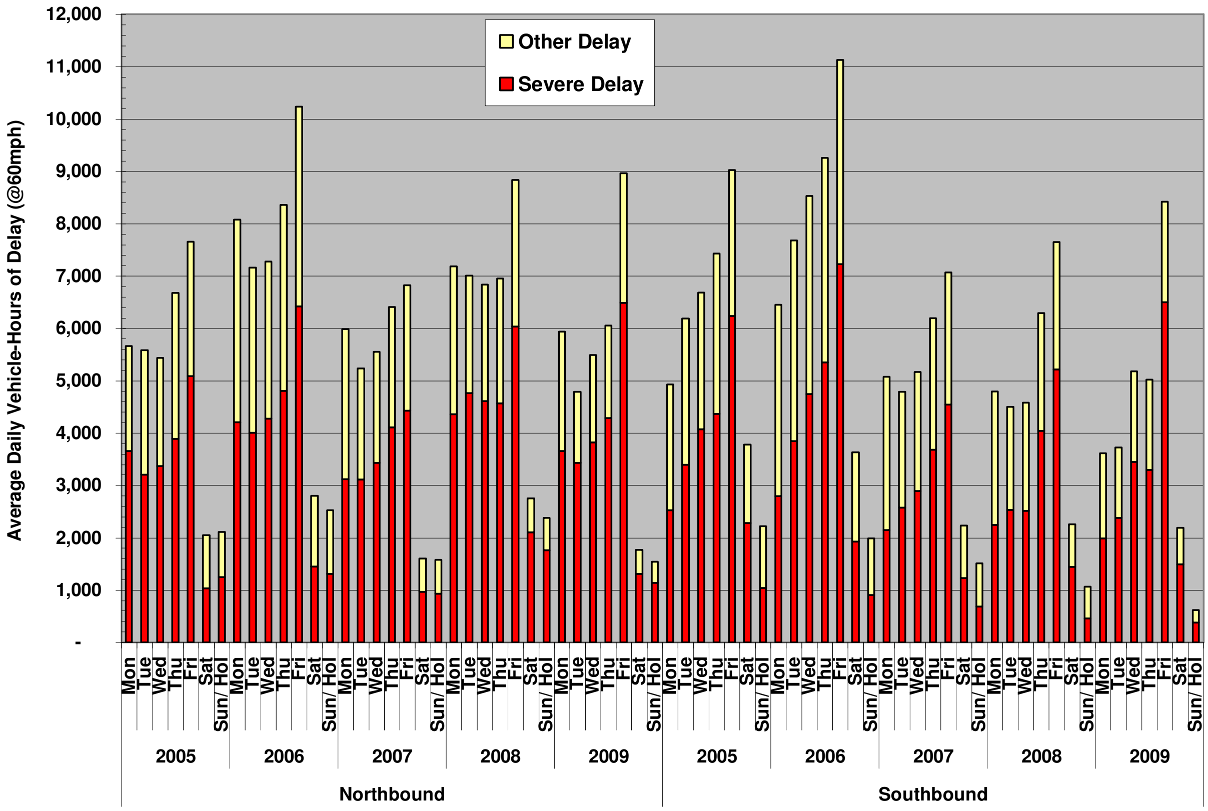
Severe delay in Exhibit 3B-8 represents breakdown conditions and is the focus of most congestion mitigation strategies. "Other" delay represents conditions approaching the breakdown congestion, leaving the breakdown conditions, or areas that cause temporary slowdowns rather than widespread breakdowns.

Exhibit 3B-8 shows average severe and other daily vehicle-hours of delay by day of the week. As depicted in the exhibit:

- Severe delay makes up about 60 percent of all weekday delay on the corridor in either the northbound or the southbound directions.
- Fridays in the southbound direction experience the highest delays, probably due to weekend travel. The second highest delays generally occurred on Thursdays.
- Delay was highest in 2006 and northbound delay tended to be greater in magnitude than southbound delay, particularly in 2007 to 2009.

Although combating congestion requires the focus on severe congestion, it is important to review "other" congestion and understand its trends. This could allow for proactive intervention before the "other" congestion turns into severe congestion.

Exhibit 3B-8: I-5 Average Delay by Day of Week by Severity (2005-2009)



Source: Caltrans detector data

Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. Exhibits 3B-9 and 3B-10 summarize average weekday hourly delay for each year over a five-year period from 2005 to 2009. Each point represents the total delay for the hour. For example, the 7:00 AM point is the sum of delay from 7:00 AM to 8:00 AM. The exhibits show the peaking characteristics of congestion and how the peak period changes over time.

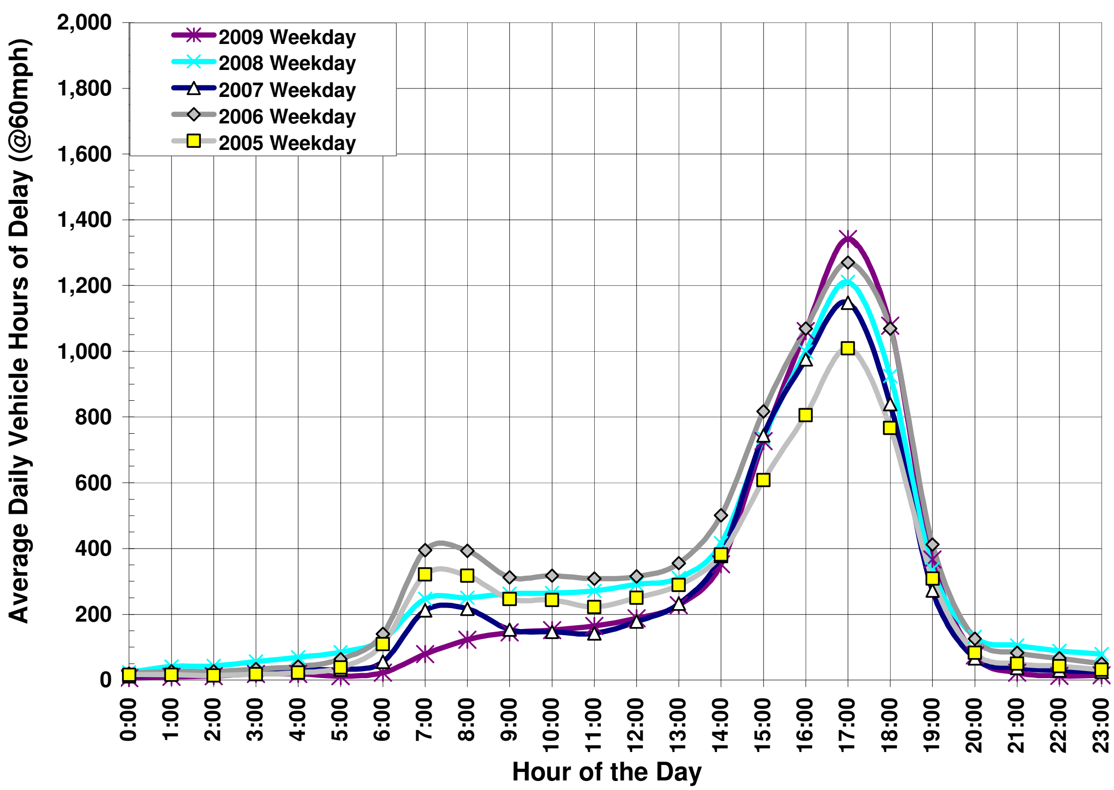
The corridor is highly directional with the northbound direction experiencing significant delay during the PM peak and the southbound direction experiencing significant delay during the AM peak period. The AM peak hour occurs between 7:00 AM and 8:00 AM, and the PM peak hour occurs between 5:00 PM and 6:00 PM. This type of directionality is typical for an urban corridor serving many work trips during the peak period.

During the 5:00 PM peak hour in the northbound direction, Exhibit 3B-9 reveals delay was highest in 2009 with about 1,375 vehicle-hours, followed by 2006 with about 1,300 vehicle-hours. The lowest level of delay was reported in 2005 at about 1,000 vehicle-hours.

Exhibit 3B-10 shows the hourly delay profile is the reverse for the southbound direction. The biggest delays occurred during the AM peak hours centered on 8:00 AM. The PM peak hours also show sizeable delays from 2:00 PM to 7:00 PM (14:00 to 19:00). This probably reflects travel on this corridor in addition to traditional nine-to-five commuting. At the 8:00 AM peak hour, 2006 experienced the highest delay with over 2,500 vehicle-hours, while 2005 to 2006 and 2007 to 2009 experienced less delay with about 900 vehicle-hours.

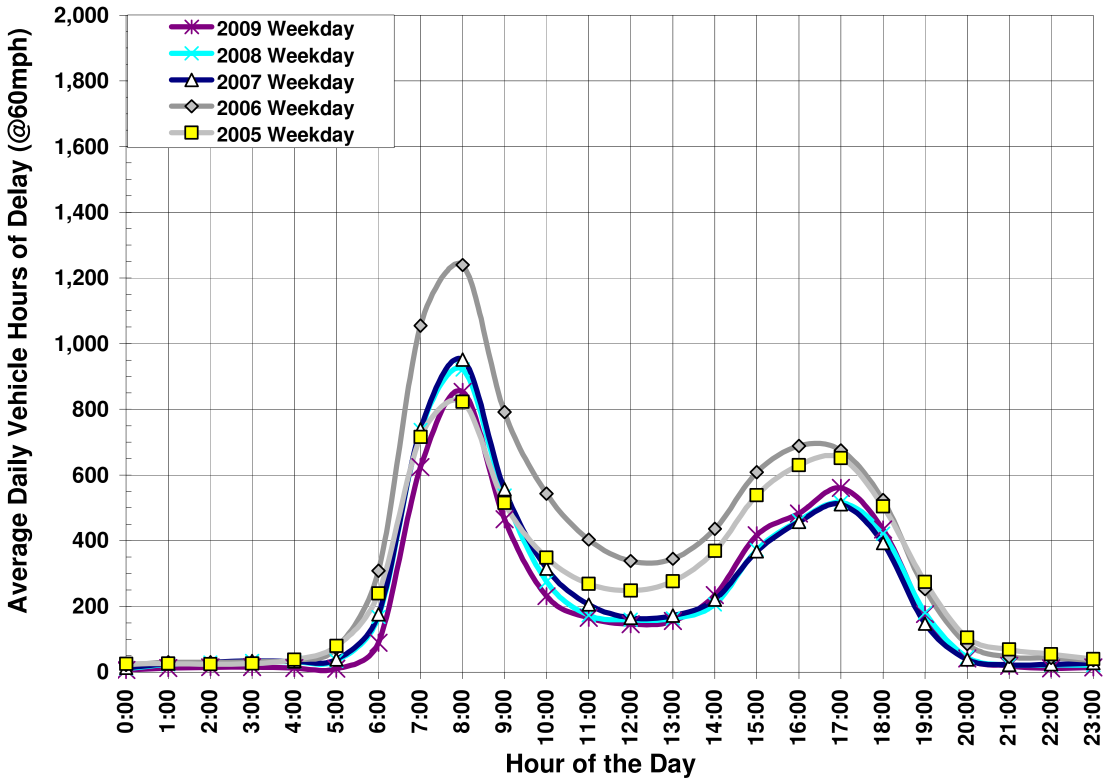
In 2009, southbound AM peak period congestion was over 30 percent less than the 2006 peak (from an estimated high of over 1,240 in 2006 to around 825 hours in 2009). However, northbound PM peak congestion in 2009 was higher than the previous years. Midday congestion is present on both directions of the corridor at about 200 to 400 hours.

Exhibit 3B-9: Northbound I-5 Average Weekday Hourly Delay (2005-2009)



Source: Caltrans detector data

Exhibit 3B-10: Southbound I-5 Average Weekday Hourly Delay (2005-2008)



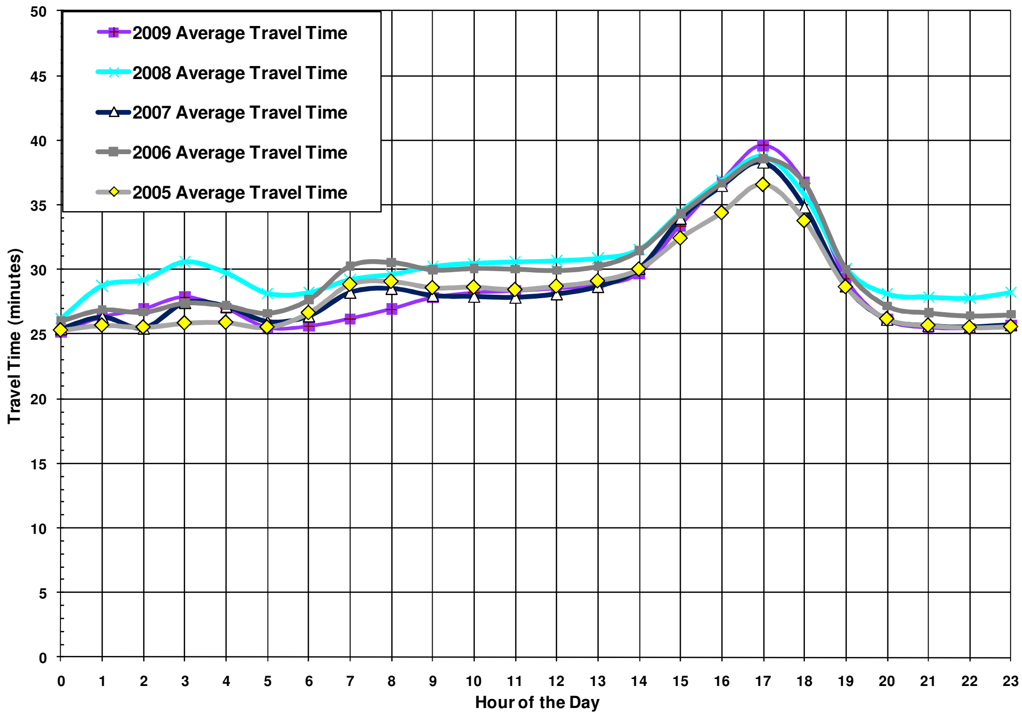
Source: Caltrans detector data

Travel Time

Travel time is reported as the amount of time it takes a vehicle to travel between two points on a corridor, as estimated using automatic detector data in this analysis. In the case of the I-5 North Corridor, the time it takes to travel 26 miles of the corridor from the I-10 to the I-210 interchange is 26 minutes traveling at 60 mph. Travel time on parallel arterials is not included in the analysis.

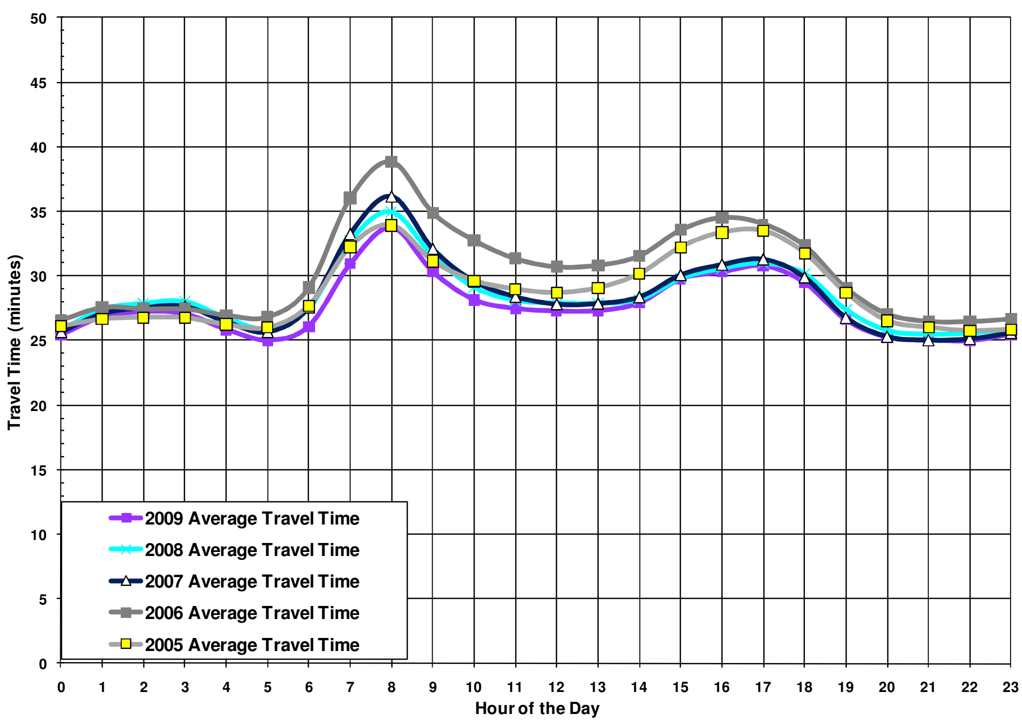
Exhibits 3B-11 and 3B-12 summarize average annual travel times estimated for the I-5 North Corridor by hour of day for the years 2005 through 2009. Similar to delay, travel times in 2009 were highest in the northbound direction during the PM peak, but lowest in the southbound direction during the AM peak.

Exhibit 3B-11: Northbound I-5 Travel Time by Hour (2005-2009)



Source: Caltrans detector data

Exhibit 3B-12: Southbound I-5 Travel Time by Hour (2005-2009)



Source: Caltrans detector data

As shown in Exhibit 3B-11, the northbound direction had typical travel times of approximately 36 to 39 minutes during the PM peak congested period. At the 5:00 PM hour, peak period travel time in the northbound direction slightly increased from 39 minutes in 2006 to 40 minutes in 2009. Overall, 2009 experienced the highest travel times of any previous year in the northbound direction.

As shown in Exhibit 3B-12, the southbound direction had travel times of approximately 34 to 39 minutes during the 8:00 AM peak hour. Unlike the northbound direction which showed that the highest travel times occurred in 2009, the southbound direction shows that travel times improved in 2009 compared to previous years. At the 8:00 AM peak hour, the travel time in 2009 was 34 minutes, which is a 5-minute improvement over the 39-minute travel time in 2006.

RELIABILITY

Reliability captures the degree of predictability in travel time. Reliability focuses on how travel time varies from day to day and reflects the impacts of accidents, incidents, weather, and special events. Improving reliability is an important goal for transportation agencies and efforts to accomplish this include incident management, traveler information, and special event planning.

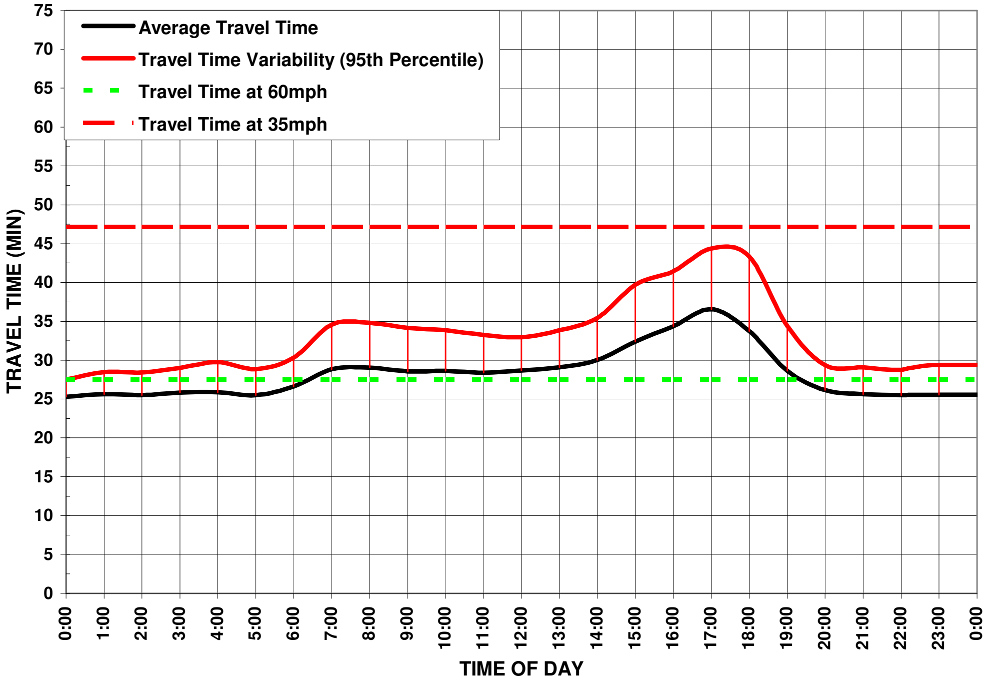
To measure reliability, the study team used automatic detector data to estimate the "buffer index." The buffer index reflects the additional time required (over and beyond the average) to ensure an on-time arrival 95 percent of the time. In other words, if a person must be on time 95 days out of 100 (or 19 out of 20 workdays per month), then that person must add additional time to their average expected travel time to ensure an on-time arrival. That additional time is the buffer time. Severe events, such as collisions, could cause longer travel times, but the 95th percentile represents a balance between days with extreme events (e.g., major accidents) and other, more "typical" travel days.

Exhibits 3B-13 through 3B-22 on the following pages illustrate the variability of travel time along the I-5 Corridor on weekdays for the years 2005 through 2009. Exhibits 3B-13 through 3B-17 present travel time variability for the northbound direction, and Exhibits 3B-18 through 3B-22 present travel time variability for the southbound direction.

In the northbound direction, the 5:00 PM peak hour was the most unreliable in addition to being the slowest hour. In 2005 (shown in Exhibit 3B-13), motorists driving the entire length of the corridor had to add 9 minutes to an average travel time of 36 minutes (for a total travel time of 45 minutes) to ensure that they arrived on time 95 percent of the time. This is 18 minutes longer than the 27-minute travel time at 60 mph. In 2006 and 2007 (Exhibits 3B-14 and 3B-15), the time needed to arrive on time 95 percent of the time remained almost the same at 44 and 45 minutes, but increased slightly in 2008 to 47 minutes (Exhibit 3B-16). It further increased to 50 minutes in 2009 (Exhibit 3B-17).

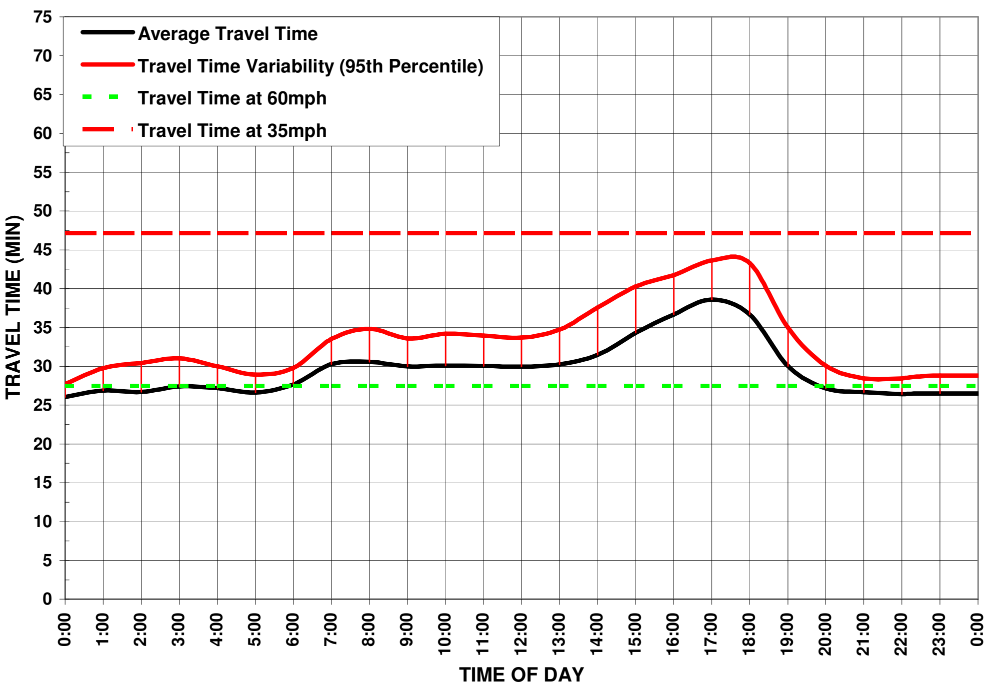
In the southbound direction, the most unreliable hour was 8:00 AM and 5:00 PM. Unlike the northbound direction which experienced the highest travel times during the PM peak period, the southbound direction experienced evenly high travel times between both AM and PM peak periods. In 2005 (Exhibit 3B-18), the time needed to arrive on time 95 percent of the time was 42 minutes at 8:00 AM and 47 minutes at 5:00 PM. In 2006 (Exhibit 3B-19), travel time variability increased to 47 minutes during both 8:00 AM and 5:00 PM hours. These variability in travel times decreased in 2007 (Exhibit 3B-20) to 44 minutes at 8:00 AM and 41 minutes at 5:00 PM. 2008 and 2009 (Exhibits 3B-21 and 3B-22) travel times variability increased again to 46 minutes at 8:00 AM and 47 minutes at the 5:00 PM peak hour.

Exhibit 3B-13: Northbound I-5 Travel Time Variation (2005)



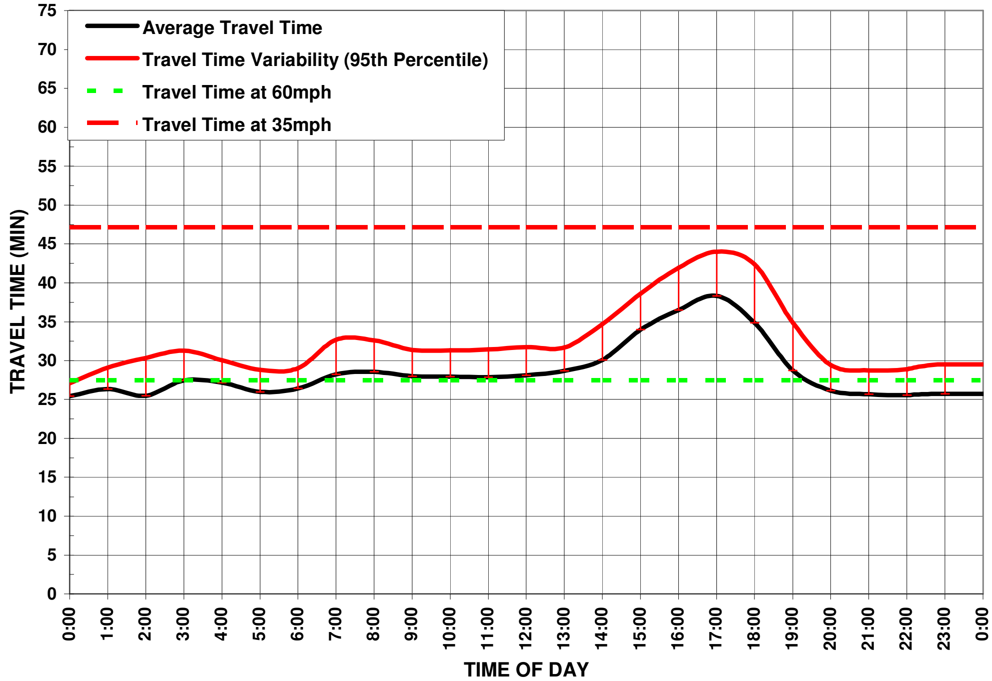
Source: Caltrans detector data

Exhibit 3B-14: Northbound I-5 Travel Time Variation (2006)



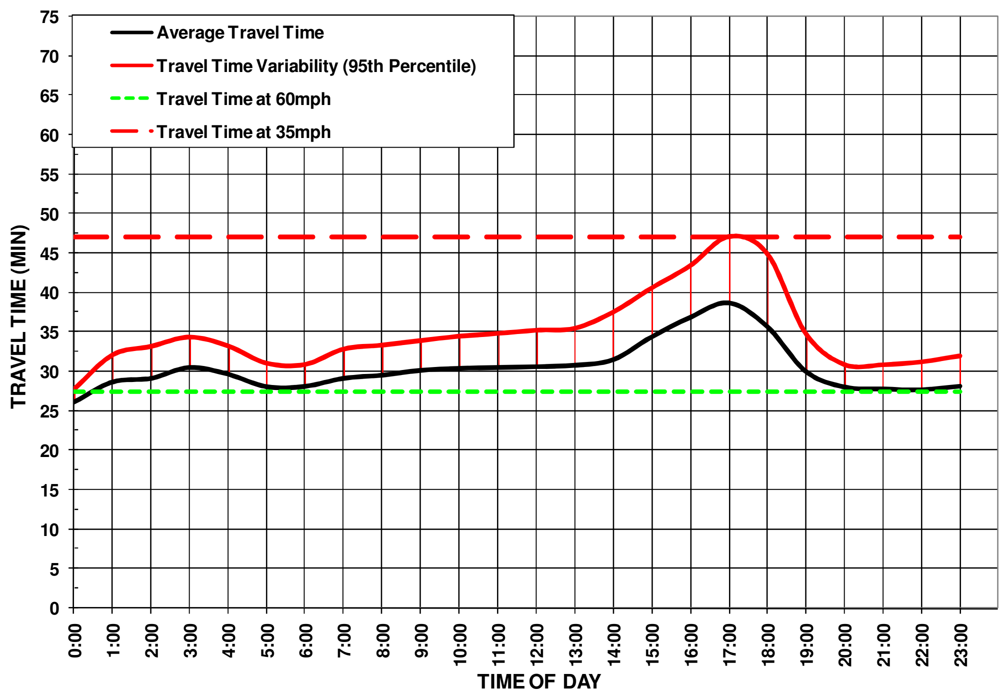
Source: Caltrans detector data

Exhibit 3B-15: Northbound I-5 Travel Time Variation (2007)



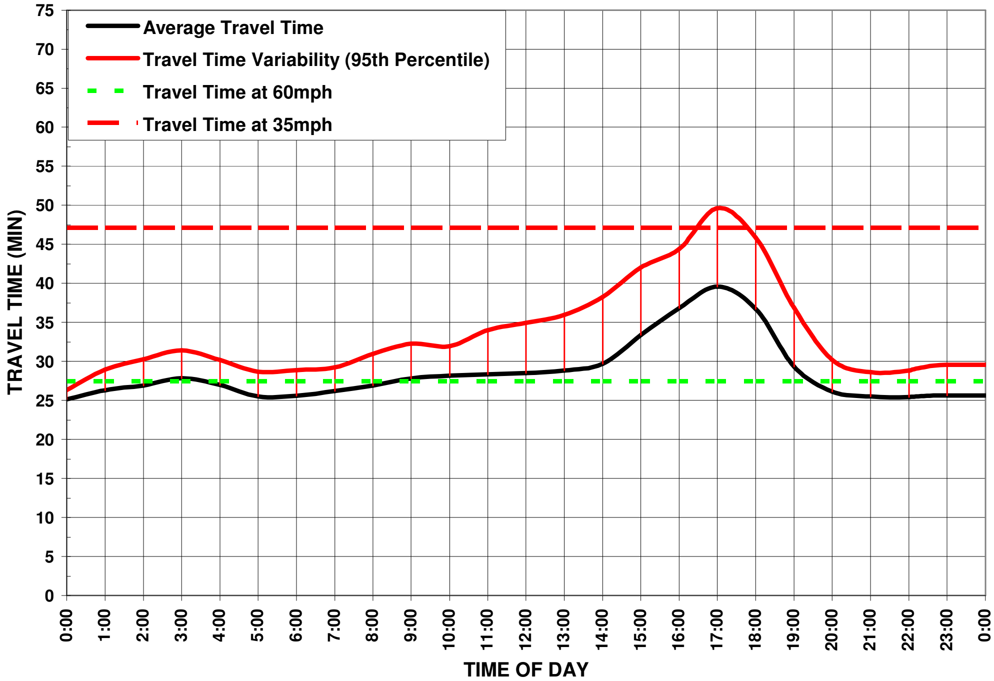
Source: Caltrans detector data

Exhibit 3B-16: Northbound I-5 Travel Time Variation (2008)



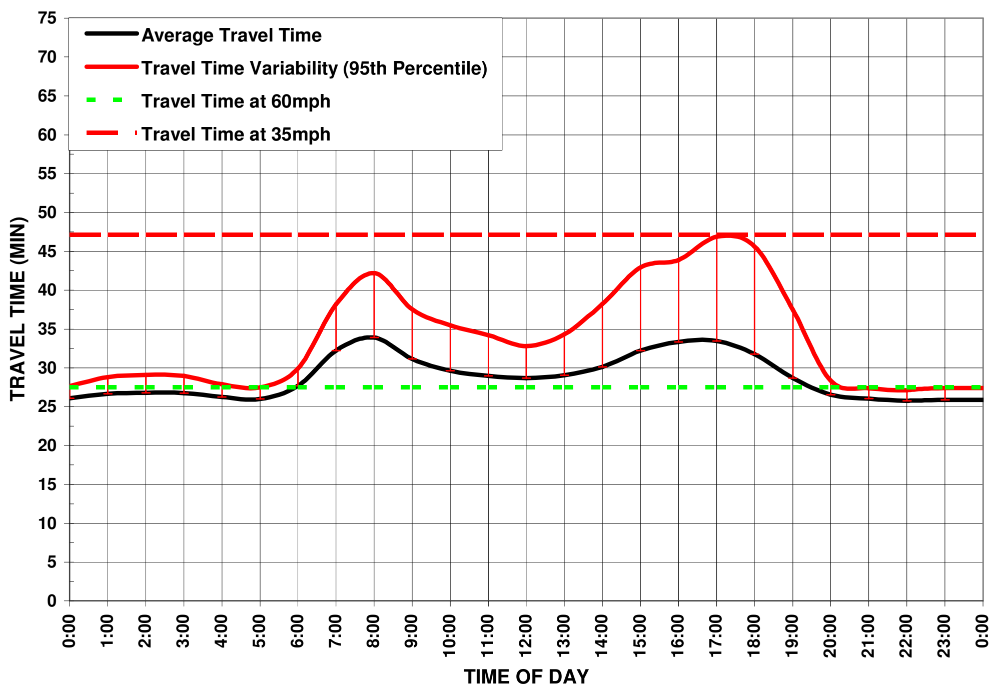
Source: Caltrans detector data

Exhibit 3B-17: Northbound I-5 Travel Time Variation (2009)



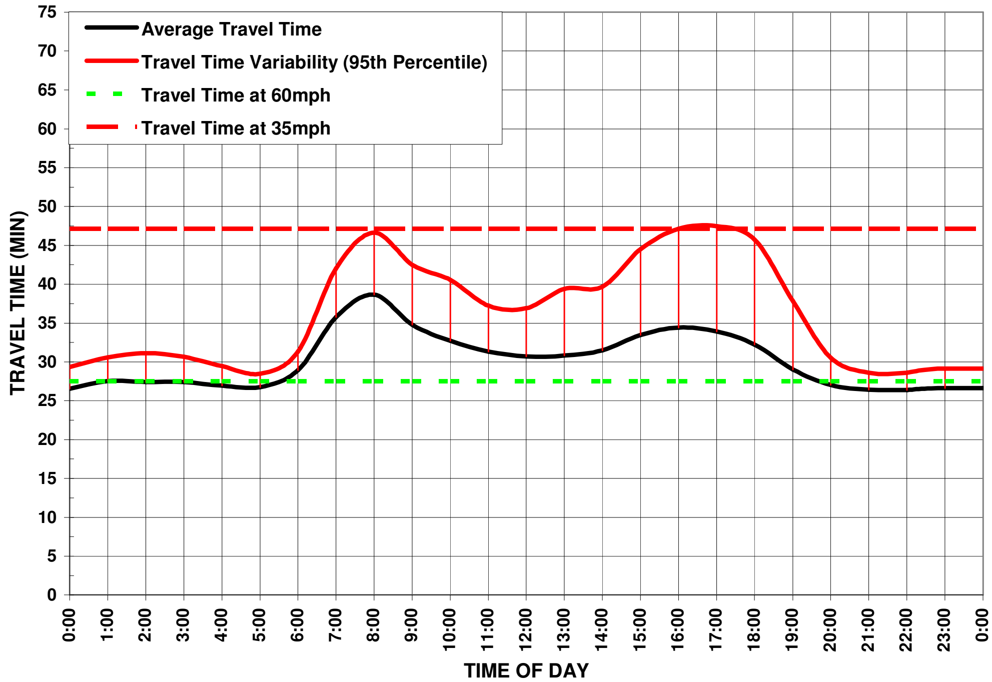
Source: Caltrans detector data

Exhibit 3B-18: Southbound I-5 Travel Time Variation (2005)



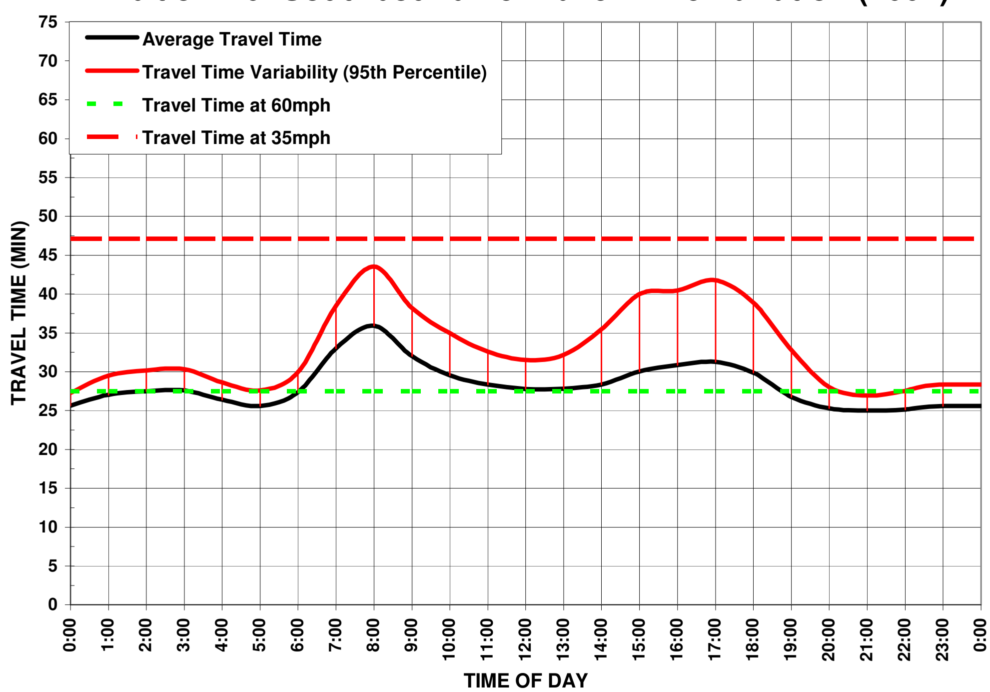
Source: Caltrans detector data

Exhibit 3B-19: Southbound I-5 Travel Time Variation (2006)



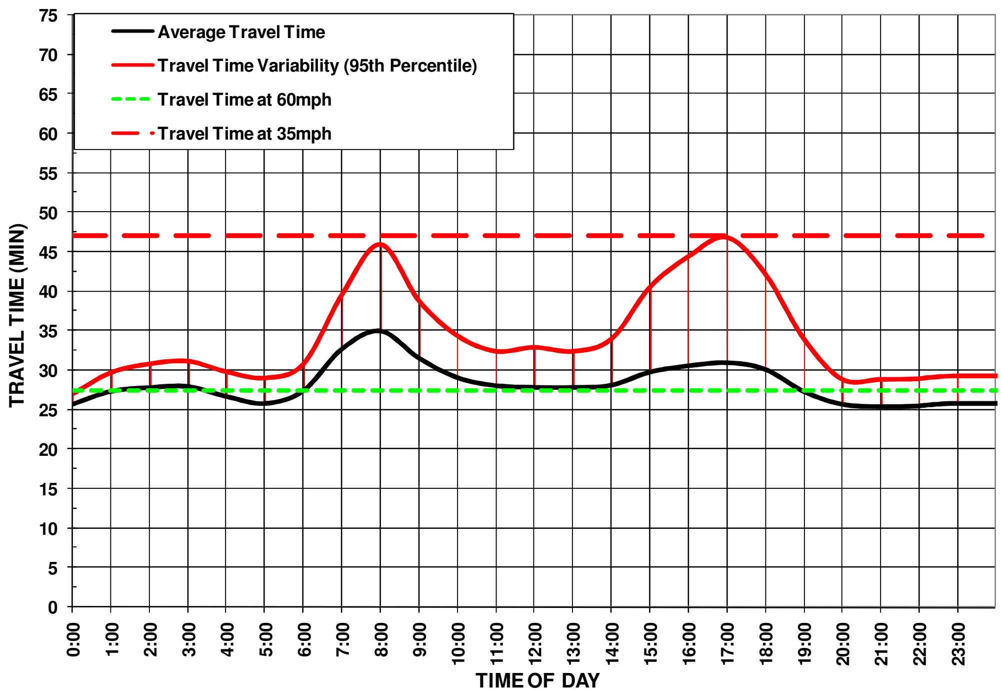
Source: Caltrans detector data

Exhibit 3B-20: Southbound I-5 Travel Time Variation (2007)



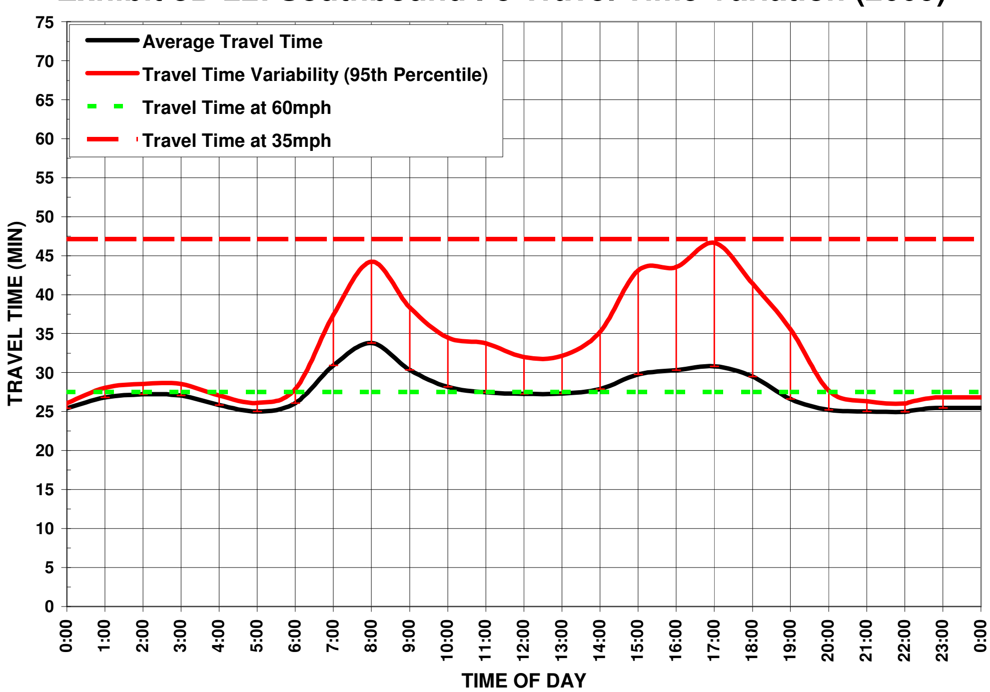
Source: Caltrans detector data

Exhibit 3B-21: Southbound I-5 Travel Time Variation (2008)



Source: Caltrans detector data

Exhibit 3B-22: Southbound I-5 Travel Time Variation (2009)



Source: Caltrans detector data

SAFETY

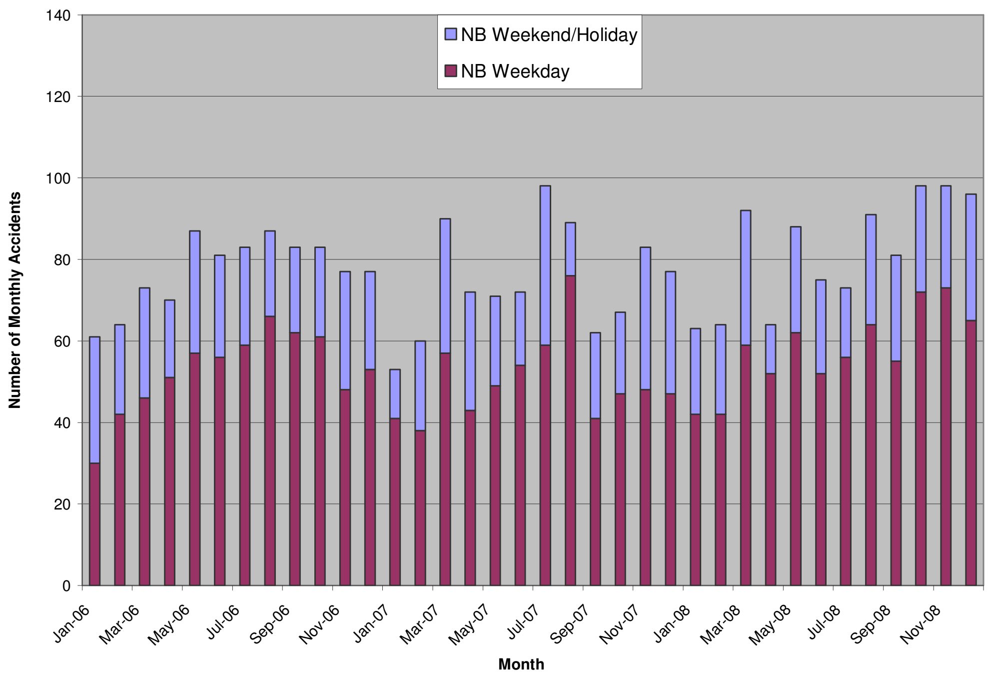
Collision data in terms of the number of accidents and accident rates from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS) were used for the safety measure. TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains description elements of highway segments, intersections and ramps, access control, traffic volumes and other data. TASAS contains specific data for accidents on state highways. Accidents on non-state highways are not included (e.g., local streets and roads).

The safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. This report is not intended to supplant more detailed safety investigations routinely performed by Caltrans staff.

Exhibits 3B-23 and 3B-24 show the number of accidents experienced on I-5 for both directions of travel by month. The monthly accidents are broken down by weekdays and weekends. Caltrans typically analyzes the latest three-year safety data. TASAS data is currently available only through December 31, 2008. Therefore, monthly data for the three-year period from January 1, 2006 through December 31, 2008 were analyzed.

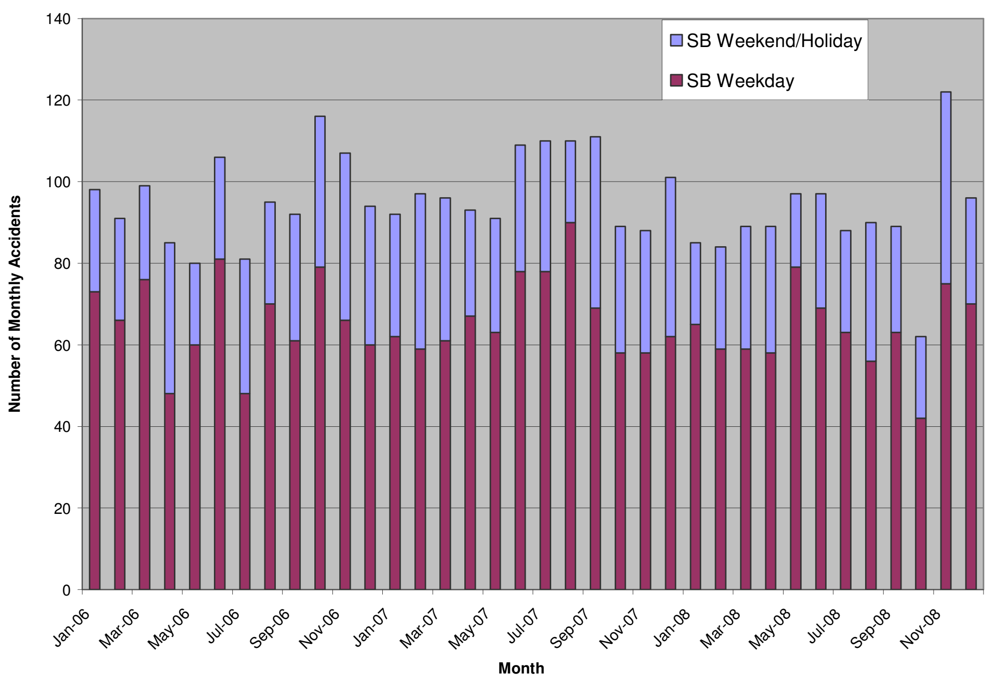
Data quality was identified earlier as a possible cause of the 2007 delay reductions. Safety is another factor. As shown in Exhibit 3B-23, the number of northbound incidents decreased from 2006 to 2007 but increased in 2008 toward the latter part of the year. This may have reduced incident-related delays. Southbound accident rates increased slightly from 2006 to 2007 and decreased from 2007 to 2008. The average monthly number of collisions during this three-year period was greater in the southbound direction.

Exhibit 3B-23: Northbound Monthly Accidents (2006-2008)



Source: Caltrans TASAS

Exhibit 3B-24: Southbound Monthly Accidents (2006-2008)



Source: Caltrans TASAS

PRODUCTIVITY

Productivity is a system efficiency measure used to analyze the capacity of the corridor, and is defined as the ratio of output (or service) per unit of input. In the case of transportation, productivity is the number of people served divided by the level of service provided. For highways, it is the number of vehicles compared to the capacity of the roadways.

For the corridor analysis, productivity is defined as the percent utilization of a facility or mode under peak conditions. The highway productivity performance measure is calculated as actual volume divided by the capacity of the highway. Travel demand models generally do not project capacity loss for highways, but detailed micro-simulation tools can forecast productivity. For highways, productivity is particularly important because the lowest “production” from the transportation system often occurs when capacity is needed the most.

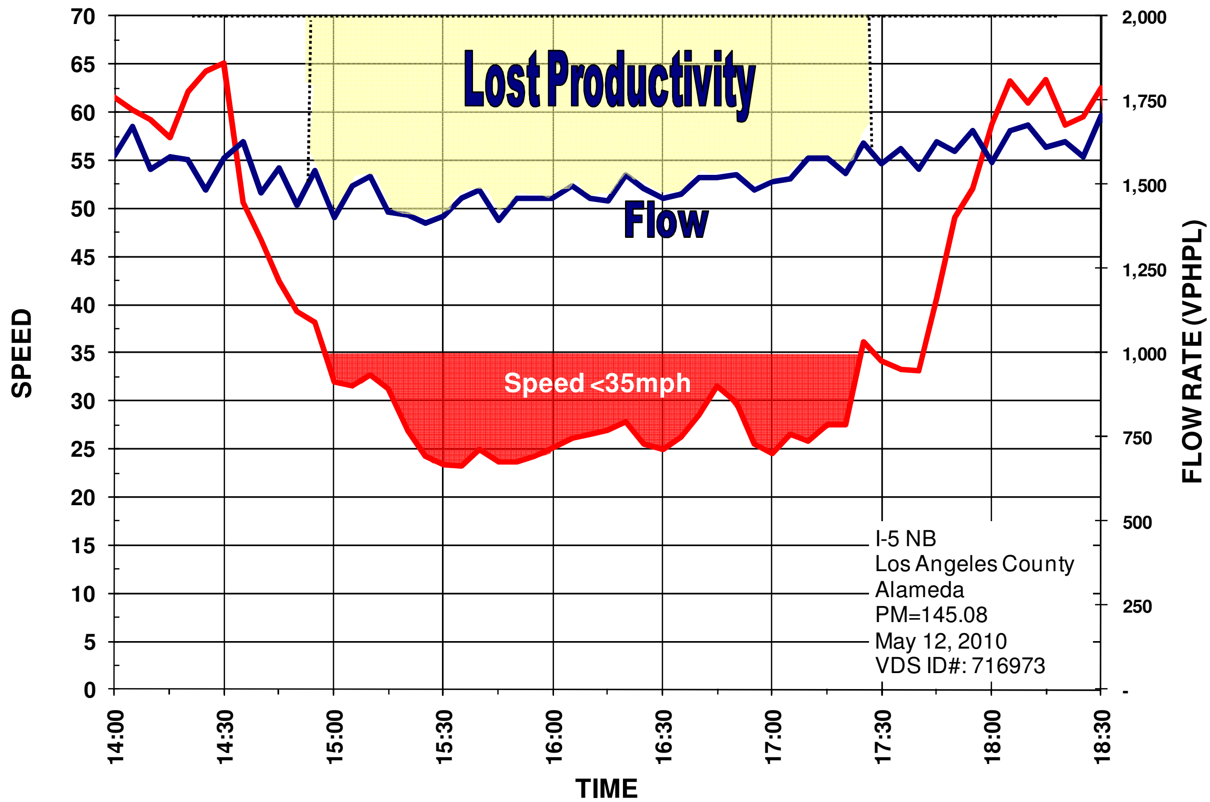
Exhibit 3B-25 illustrates how congestion leads to lost productivity. As traffic flows increase to the capacity limits of a roadway, speeds decline rapidly and throughput drops dramatically. The exhibit uses observed data from I-5 sensors for a typical afternoon 2010 peak period (May 12, 2010). It shows speeds (in red) and flow rates (in blue) on northbound I-5 at Alameda Avenue, one of the most congested locations on the corridor.

Flow rates (measured as vehicle-per-hour-per-lane or “vphpl”) at Alameda Avenue averaged slightly over 1,650 vphpl between 2:00 PM and 2:30 PM, which is slightly less than a typical peak period maximum flow rate. Generally, freeway flow rates over 2,000 vehicles per hour per lane cannot be sustained over a long period.

Once volumes approach this maximum rate, traffic becomes unstable. With any additional merging or weaving, traffic breaks down and speeds can rapidly plummet to below 35 mph. In essence, every incremental merge takes up two spots on the freeway for a short time. However, since the volume is close to capacity, these merges lead to queues. Rather than accommodating the same number of vehicles, flow rates also drop and vehicles back up, creating bottlenecks and associated congestion.

There are a few ways to estimate productivity losses. One approach is to convert this lost productivity into “equivalent lost lane-miles.” At the location shown in Exhibit 3B-25, throughput drops by nearly 10 percent on average during the peak period (from over 1,650 to around 1,500 vphpl). This four-lane road therefore operates with 10 percent less capacity when demand is at its highest. Just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost lanes. This loss in throughput can be aggregated and presented as “equivalent lost-lane-miles”. Regardless of the approach, productivity calculations require good detection or significant field data collection at congested locations.

Exhibit 3B-25: Lost Productivity Illustrated on I-5 North Corridor



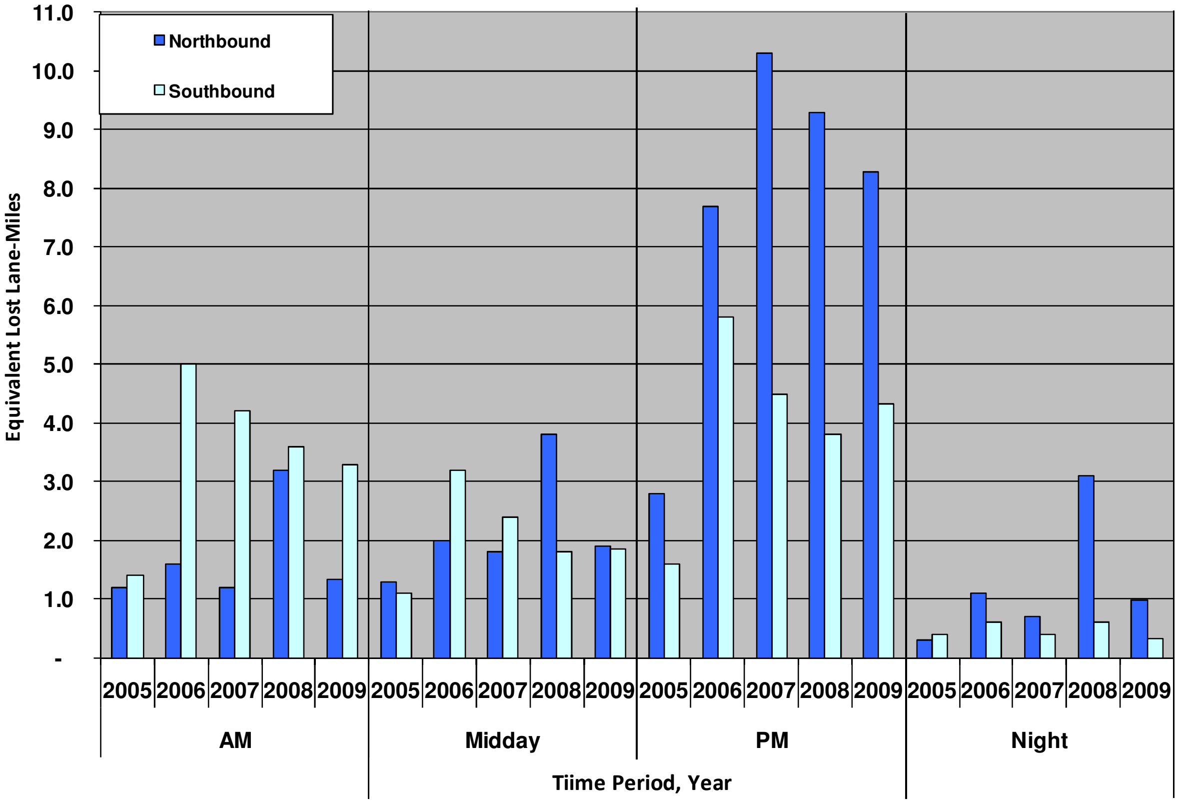
Equivalent lost lane-miles is computed as follows (for congested locations only):

$$LostLaneMiles = \left(1 - \frac{ObservedLaneThroughput}{2000vphpl}\right) \times Lanes \times CongestedDistance$$

Strategies to combat such productivity losses are primarily related to operations. These strategies include: building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improving incident clearance times.

Exhibit 3B-26 summarizes the productivity losses on the I-5 Corridor from 2005 to 2009. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the PM peak hours in the northbound direction (as noted by the taller blue-colored bars), which is the time period and direction that experienced the most congestion, or delay. This exhibit also shows that the southbound direction was least productive during the AM and the northbound direction least productive during the PM peak.

Exhibit 3B-26: I-5 Daily Equivalent Lost Lane-Miles by Direction and Period (2005-2009)



Source: Caltrans detector data

C. Pavement Condition

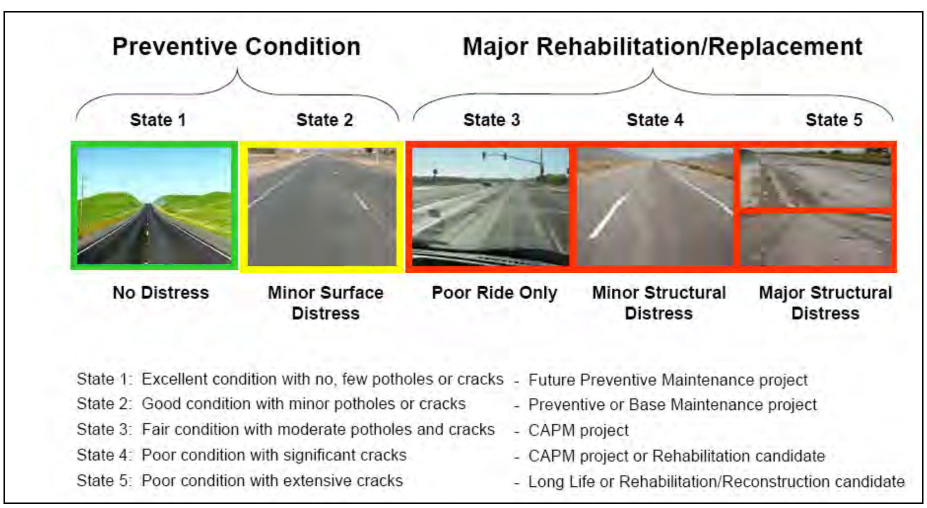
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation refers to maintaining the structural adequacy and ride quality of the pavement. It is possible for a roadway section to have structural distress without affecting ride quality. Likewise, a roadway section may exhibit poor ride quality, while the pavement remains structurally adequate.

PAVEMENT PERFORMANCE MEASURES

Caltrans conducts an annual Pavement Condition Survey (PCS) that can be used to compute two performance measures commonly estimated by Caltrans: distressed lane-miles and International Roughness Index (IRI). Although Caltrans generally uses distressed lane-miles for external reporting, this report uses the Caltrans data to present results for both measures.

Using distressed lane-miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3C-1 provides an illustration of this distinction. The first two pavement conditions include roadways that provide adequate ride quality and are structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3C-1: Pavement Condition States Illustrated



Source: Caltrans Division of Maintenance, 2007 State of the Pavement Report

IRI distinguishes between smooth-riding and rough-riding pavement. The distinction is based on measuring the up and down movement of a vehicle over pavement. When such movement is measured at 95 inches per mile or less, the pavement is considered good or smooth-riding. When movements are between 95 and 170 inches per mile, the pavement is considered acceptable. Measurements above 170 inches per mile reflect unacceptable or rough-riding conditions.

EXISTING PAVEMENT CONDITIONS

The most recent pavement condition survey, completed in November 2007, identified 12,998 distressed lane-miles statewide. Unlike prior surveys, the 2007 PCS included pavement field studies for a period longer than a year, due to an update in the data collection methodology. The survey includes data for 23 months from January 2006 to November 2007.

The field work consists of two parts. In the first part, pavement raters visually inspect the pavement surface to assess structural adequacy. In the second part, field staff uses vans with automated profilers to measure ride quality. The 2007 PCS revealed that the majority of distressed pavement was on freeways and expressways (Class 1 roads). This is the result of approximately 56 percent of the State Highway System falling into this road class. As a percentage of total lane-miles for each class, collectors and local roads (Class 3 roads) had the highest amount of distress.

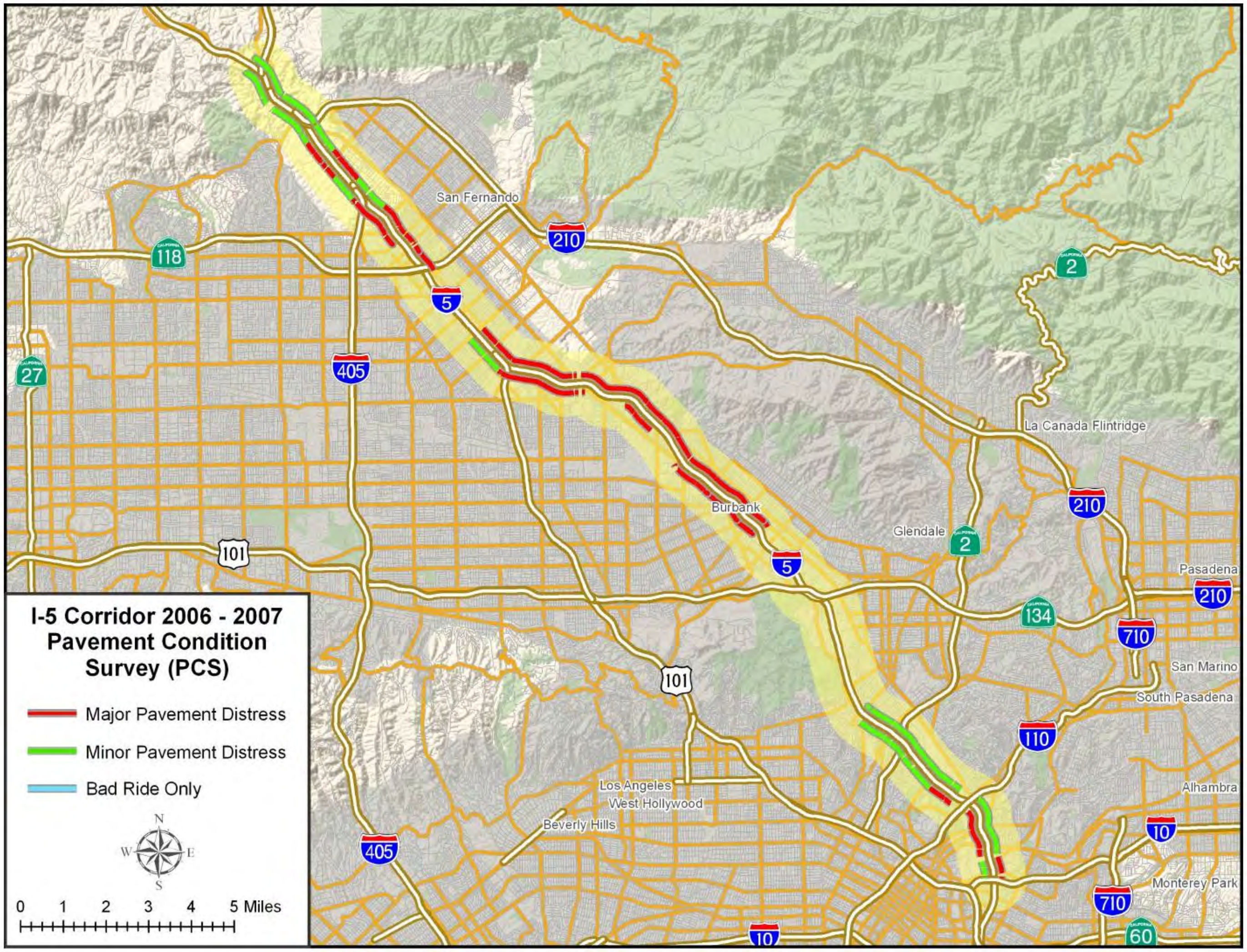
Exhibit 3C-2 shows pavement distress along the I-5 Corridor according to the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3C-1.

The I-5 Corridor shows more pavement distress than does the typical freeway in District 7. Just over half of the corridor has at least one lane exhibiting major pavement distress. The major distress can be grouped into three subsections along the corridor. The first section includes about four centerline miles north of SR-118. The second section is longer and found between SR-118 and SR-134. The third section includes about two miles north of downtown Los Angeles near I-110. The distress along the rest of the corridor is minor and no sections exhibit only ride quality issues.

Exhibit 3C-3 shows results from prior pavement condition surveys along the study corridor. The number of distressed lane-miles generally increased since 2003. Most of the growth is due to an increase in major pavement distress. Ride quality only issues have not appeared since 2003 and have been replaced by minor pavement issues.

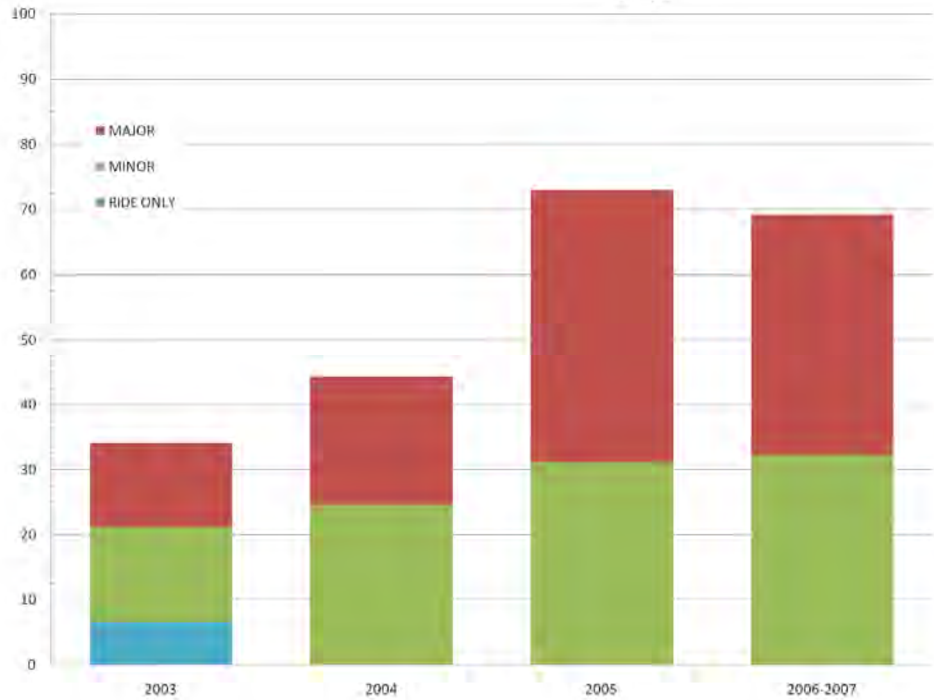
The change in the percent mix of distressed lane-miles is shown more clearly in Exhibit 3C-4. As seen in the exhibit, distress is split roughly evenly between major and minor pavement issues.

Exhibit 3C-2: Distressed Lane-Miles on I-5 North Corridor (2006-2007)



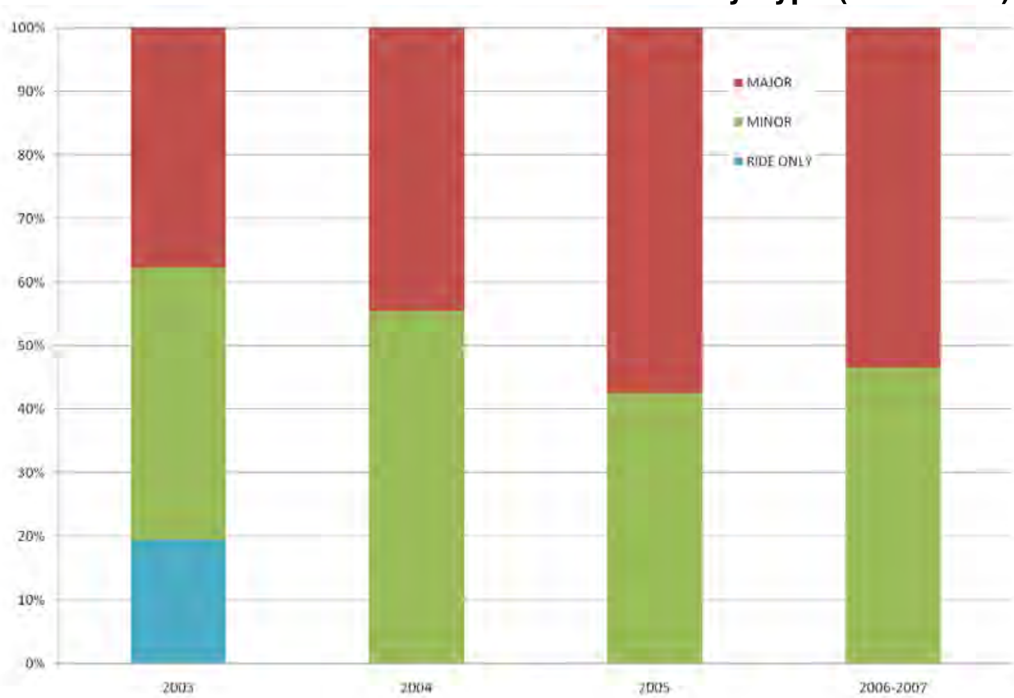
Source: Pavement Condition Survey data

Exhibit 3C-3: I-5 North Distressed Lane-Miles Trends (2003-2007)



Source: Pavement Condition Survey data

Exhibit 3C-4: I-5 North Distressed Lane-Miles by Type (2003-2007)



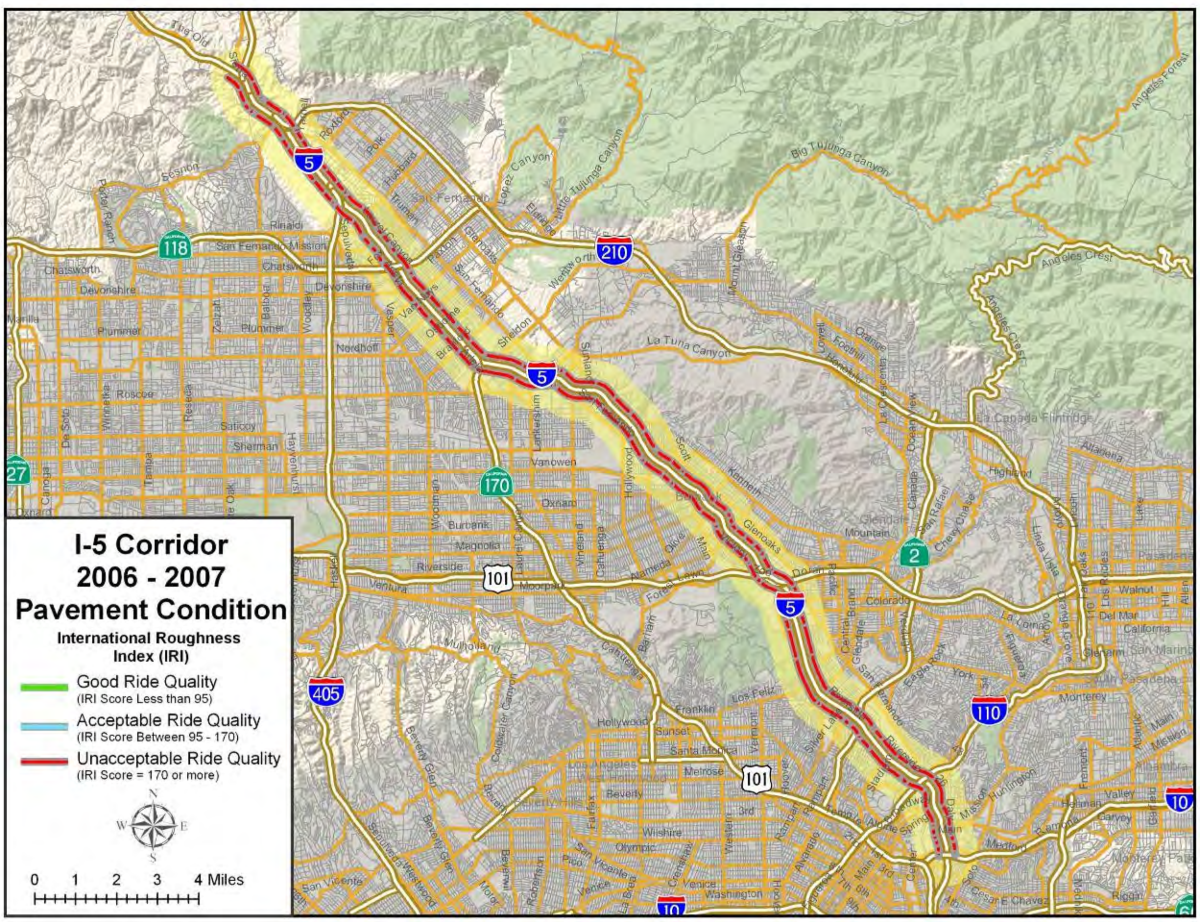
Source: Pavement Condition Survey data

Exhibit 3C-5 shows IRI along the study corridor for the lane with the poorest pavement condition in each freeway segment. The poorest pavement conditions are shown in the exhibit because pavement investment decisions are made on this basis. As the exhibit shows, the entire corridor has ride quality issues (IRI greater than 170). Not all of these sections appear in Exhibit 3C-5 due to algorithms and thresholds in the PCS.

When the conditions on all lanes are considered, the study corridor comprises roughly 221 lane-miles, of which:

- 101 lane-miles, or 46 percent, are considered to have good ride quality (IRI ≤ 95)
- 86 lane-miles, or 39 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 34 lane-miles, or 15 percent, are considered to have unacceptable ride quality (IRI > 170)

Exhibit 3C-5: I-5 North Road Roughness (2006-2007)

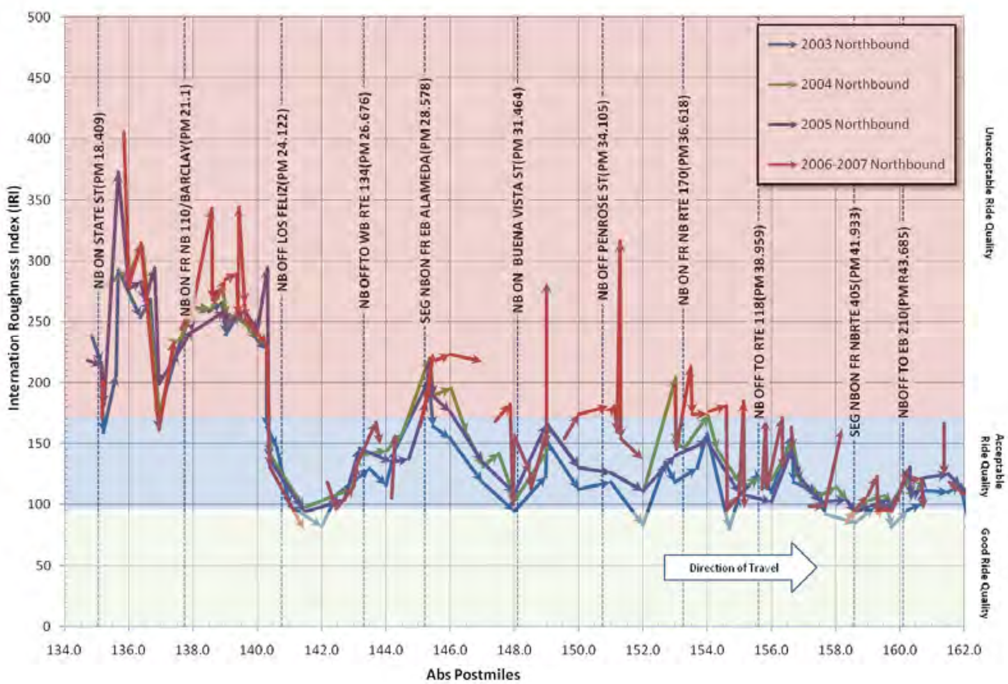


Source: Pavement Condition Survey data

Exhibits 3C-6 and 3C-7 present ride conditions for the I-5 North CSMP Corridor using IRI from the last four pavement surveys. The information is presented by Post Mile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The surveys show consistent patterns of good, acceptable, and unacceptable ride quality. Ride quality has worsened slightly over the last few surveys, but this is expected with the aging of the freeway.

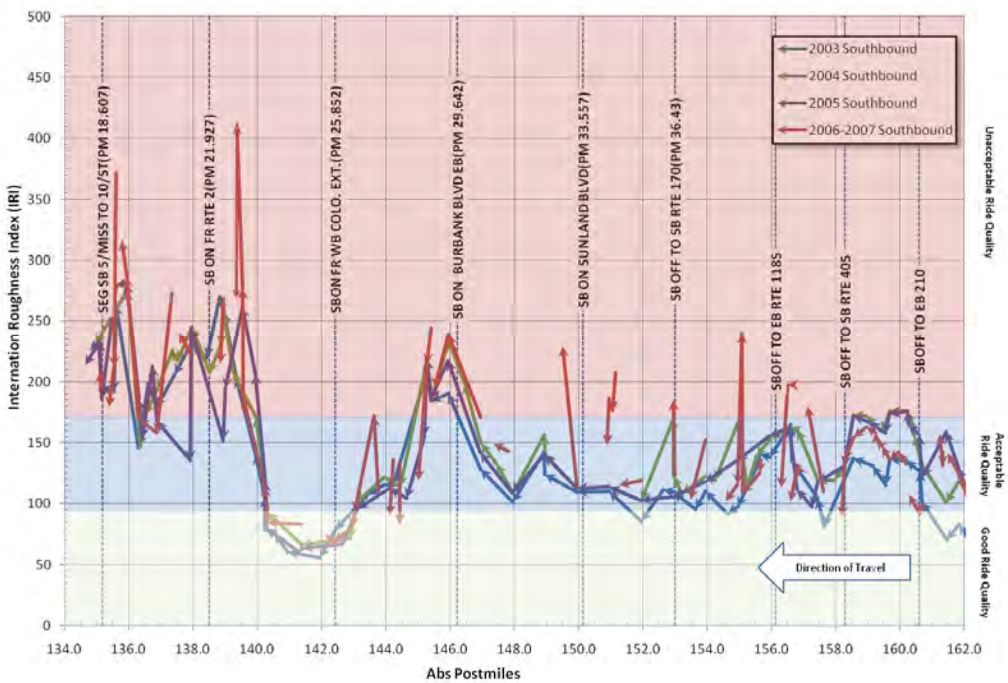
The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) in the 2006-07 period.

Exhibit 3C-6: Northbound I-5 North Road Roughness (2003-2007)



Source: Pavement Condition Survey data

Exhibit 3C-7: Southbound I-5 North Road Roughness (2003-2007)



Source: Pavement Condition Survey data

4. BOTTLENECK IDENTIFICATION & CAUSALITY ANALYSIS

A. Bottleneck Identification

Major bottlenecks are the primary cause of congestion and lost productivity. A bottleneck is a location where traffic demand exceeds the effective carrying capacity of the roadway. In most cases, the cause of a bottleneck relates to a sudden reduction in capacity, such as a lane drop, merging and weaving, driver distractions, a surge in demand, or a combination of factors.

Los Angeles I-5 North Corridor bottlenecks were identified and verified during 2007 and 2008 based on a variety of data sources, including State Highway Congestion Monitoring Program (HICOMP) data, Caltrans District 7 probe vehicle runs, automatic detector data, and extensive consultant team field observations and video-taping.

Potential bottleneck locations were initially identified in the Preliminary Performance Assessment report delivered in 2008. The Comprehensive Performance Assessment delivered in 2009 presented the results of additional analysis and extensive field observations.

The study team conducted the field observations, videotaping major bottlenecks to document the locations and potential causes of the bottlenecks. These efforts resulted in confirming consistent sets of bottlenecks for both directions of the freeway. Exhibit 4A-1 summarizes the bottleneck locations identified in this analysis and their associated delays. Exhibits 4A-2 and 4A-3 are maps showing these bottleneck locations for the AM and PM peak periods, respectively.

Exhibit 4A-1: I-5 North Corridor Bottlenecks

Dir	Abs PM	CA PM	Bottleneck Location	Active Period AM	Active Period PM
Northbound	135.2	18.6	I-10 On		✓
	138.0	21.3	SR-110 On	✓	✓
	143.5	26.8	SR-134 On		✓
	145.2	28.6	Alameda On		✓
	152.7	36.1	Sheldon On		✓
	153.9	37.2	Osborne Off	✓	✓
	155.6	38.9	SR-118 Off		✓
Dir	**Abs PM**	**CA PM**	**Bottleneck Location**	**Active Period AM**	**Active Period PM**
Southbound	155.5	38.9	SR-118 On	✓	
	153.0	36.4	SR-170 Off	✓	
	143.5	26.9	SR-134 Off		✓
	139.3	22.7	SR-2 Off	✓	✓
	138.5	21.9	SR-2 On	✓	✓
	137.6	21.0	SR-110 Off	✓	✓

Exhibit 4A-2: Map of Major AM Bottlenecks on I-5 North Corridor

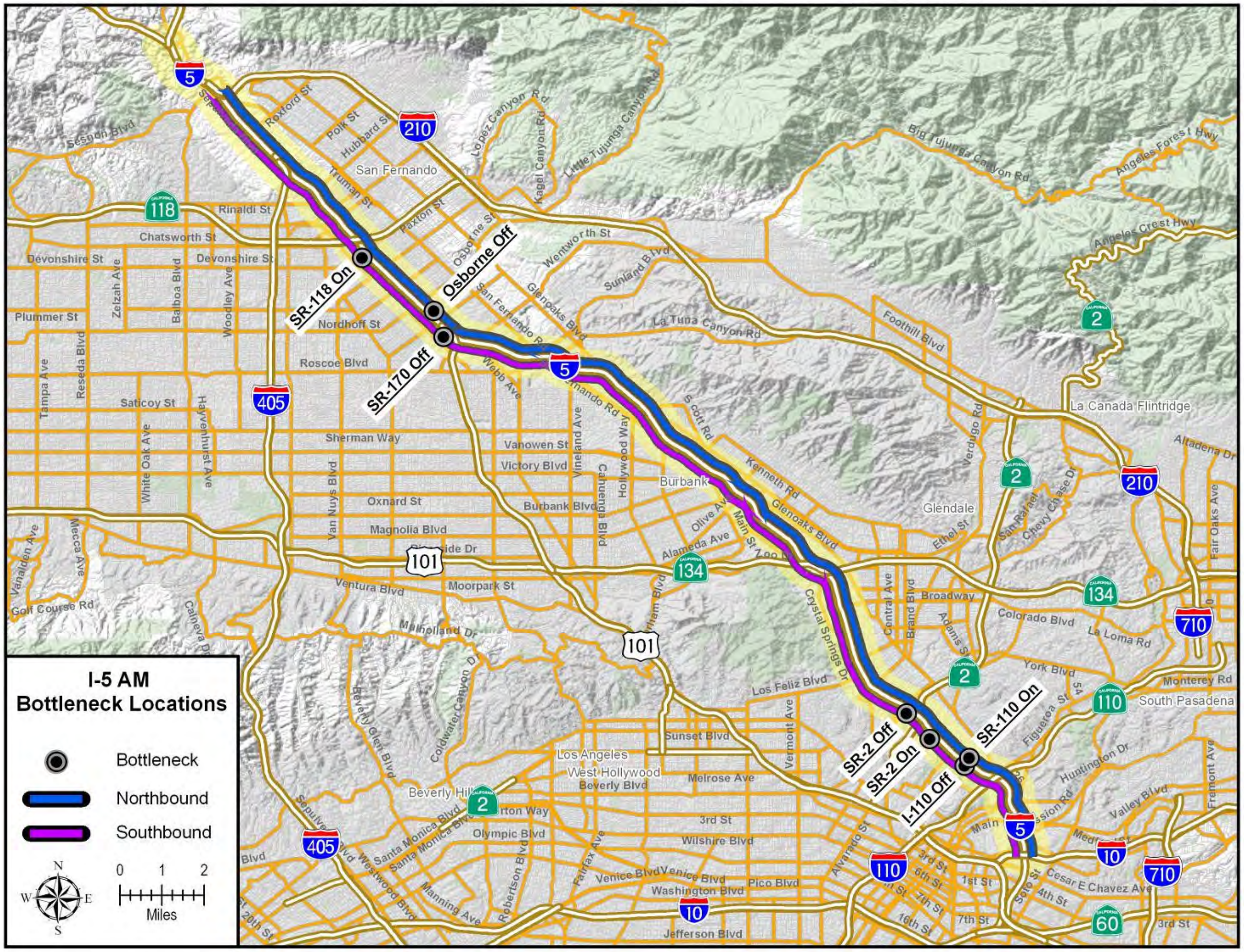
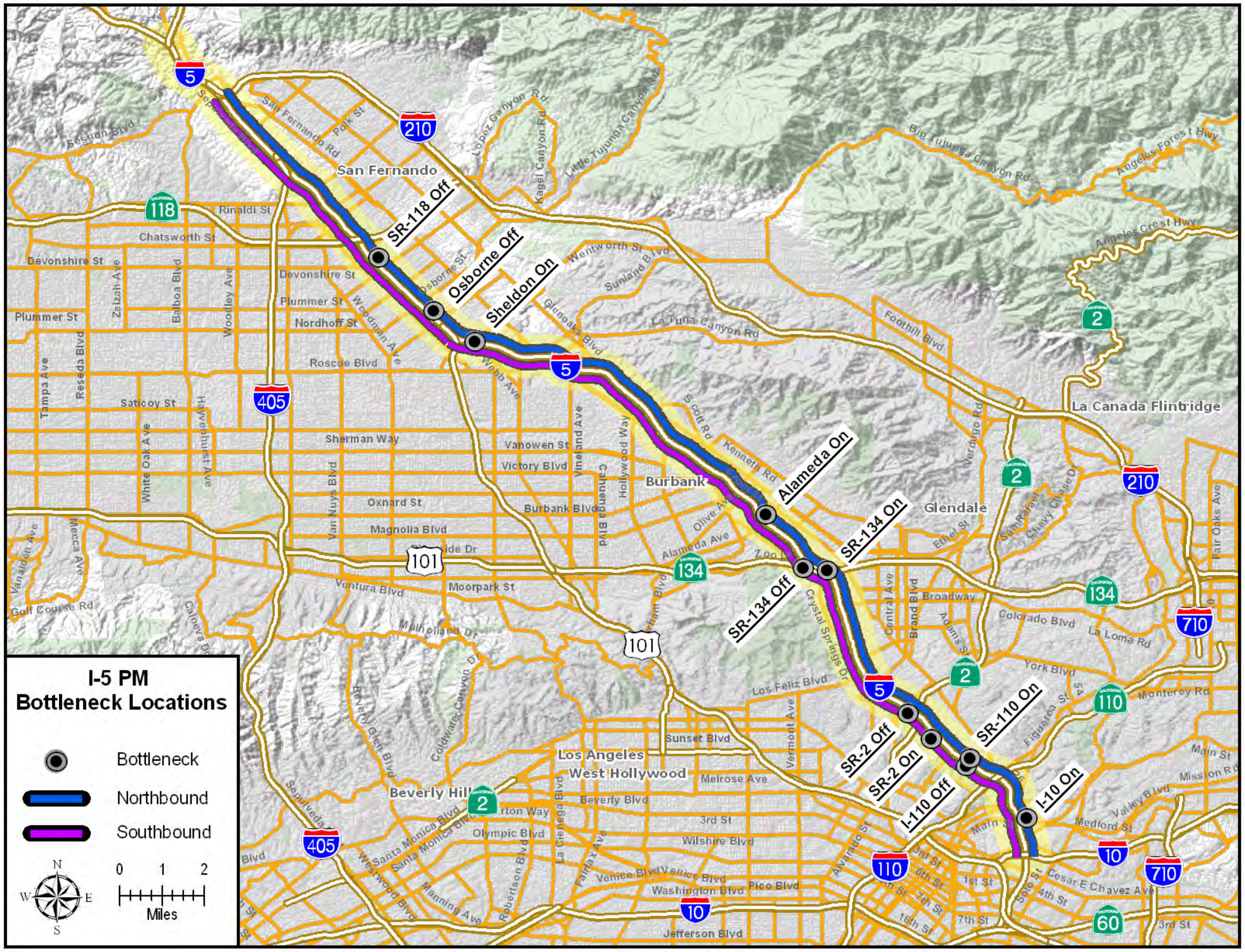


Exhibit 4A-3: Map of Major PM Bottlenecks on I-5 North Corridor



This section of the report presents the initial bottleneck identification analysis performed as part of the Preliminary Performance Assessment.

A variety of sources were used to identify bottlenecks. They include:

- State Highway Congestion Monitoring Program (HICOMP) 2006 report
- Freeway Performance Measurement System (PeMS)
- Aerial photos (Google Earth) and Caltrans photologs.

Highway Congestion Monitoring Program

The State Highway Congestion Monitoring Program (HICOMP) annual report was the first tool used by the study team to identify problem areas. Published annually since 1987, HICOMP attempts to measure “typical” peak period, weekday, and recurring traffic congestion on urban area freeways. HICOMP does not include congestion on other state highways or local surface streets. Non-recurrent congestion such as holiday, maintenance, construction or special-event generated traffic congestion is also not included. HICOMP data is useful for finding general trends and making regional comparisons of freeway performance, but some estimates presented in the report are based on a limited number of observations. Furthermore, HICOMP does not attempt to capture bottleneck locations, but simply report on locations of likely recurrent congestion.

Using the 2006 HICOMP data, potential problem areas were initially identified. As illustrated in Exhibit 4A-4 and 4A-5, the downstream end of congested segments were initially considered bottleneck areas in the northbound direction (shown with blue circles) and in the southbound direction (shown with red circles).

Exhibit 4A-4: HICOMP AM Congestion Map with Potential Bottlenecks (2006)

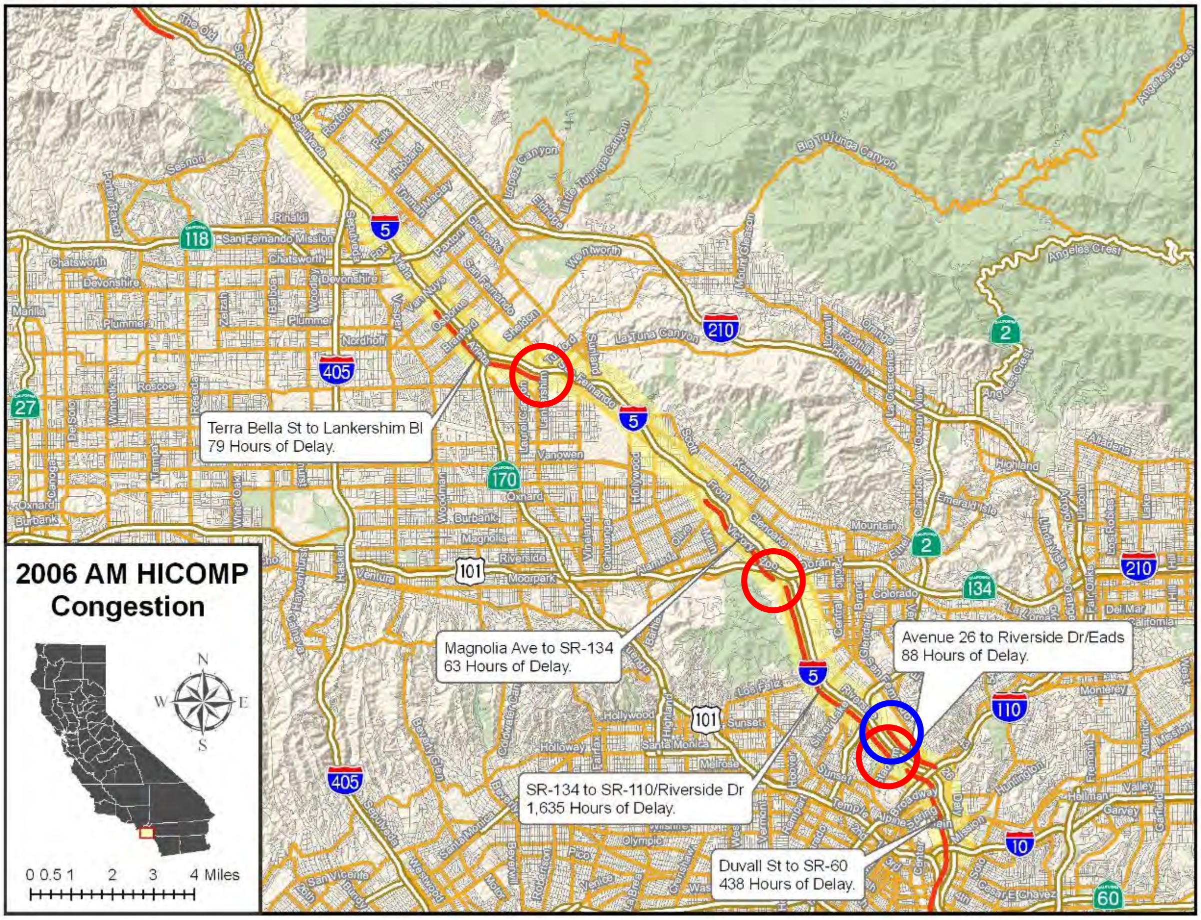
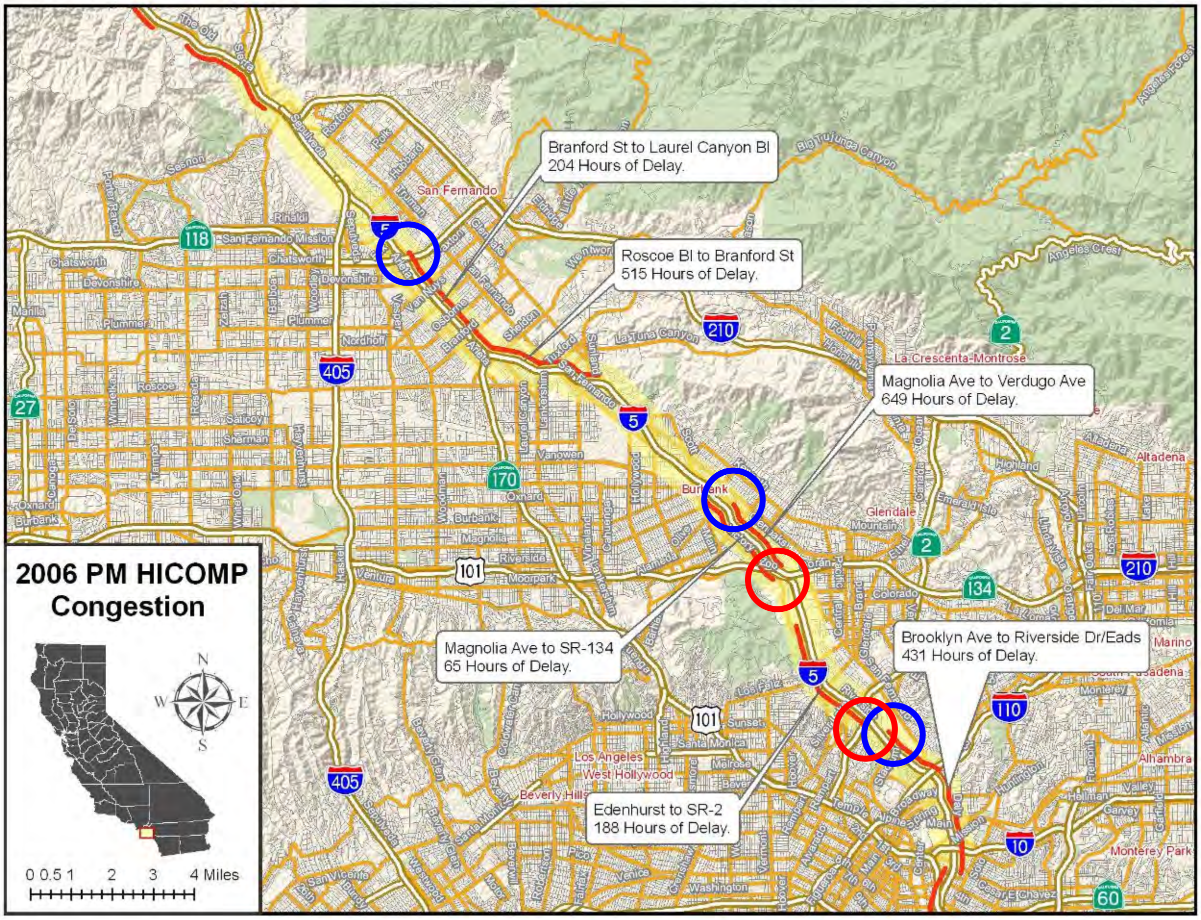


Exhibit 4A-5: HICOMP PM Congestion Map with Potential Bottlenecks (2006)



Probe Vehicle Runs

The probe vehicle runs (electronic tachometer runs) provide speed plots across the corridor at various departure times. A vehicle equipped with an electronic (GPS or tachometer) device is driven along the corridor at various departure times, typically in a middle lane, during the peak period, at regular, 20 to 30 minute intervals. Actual speeds are recorded as the vehicle traverses the corridor. Bottlenecks can be found at the end of congested segment, where speeds generally increase from about 30 miles per hour to 50 miles per hour.

Caltrans District 7 collected probe vehicle run data in April 2000 for the I-5 freeway from the Downtown Los Angeles to the I-210 interchange. The freeway corridor runs were broken into two separate segments from the I-10 to Buena Vista and Buena Vista to the I-210 interchange. For each segment, the runs were conducted from approximately 5:30 AM to 11:00 AM and from 2:30 PM to 7:30 PM. Exhibit 4A-6 illustrates the I-5 northbound probe vehicle runs conducted on separate days in April 2000 at specific time intervals: run at 7:00 AM, 8:00 AM, 9:00 AM, 4:00 PM, 5:00 PM and 6:00 PM. There are slow speeds (congestion) and bottleneck evident only in the PM peak hours in the northbound direction. However, these probe vehicle runs could be capturing entirely different condition than automatic detector data, since they were collected several years earlier.

Exhibit 4A-6: Northbound I-5 Sample Probe Vehicle Runs (April 2000)

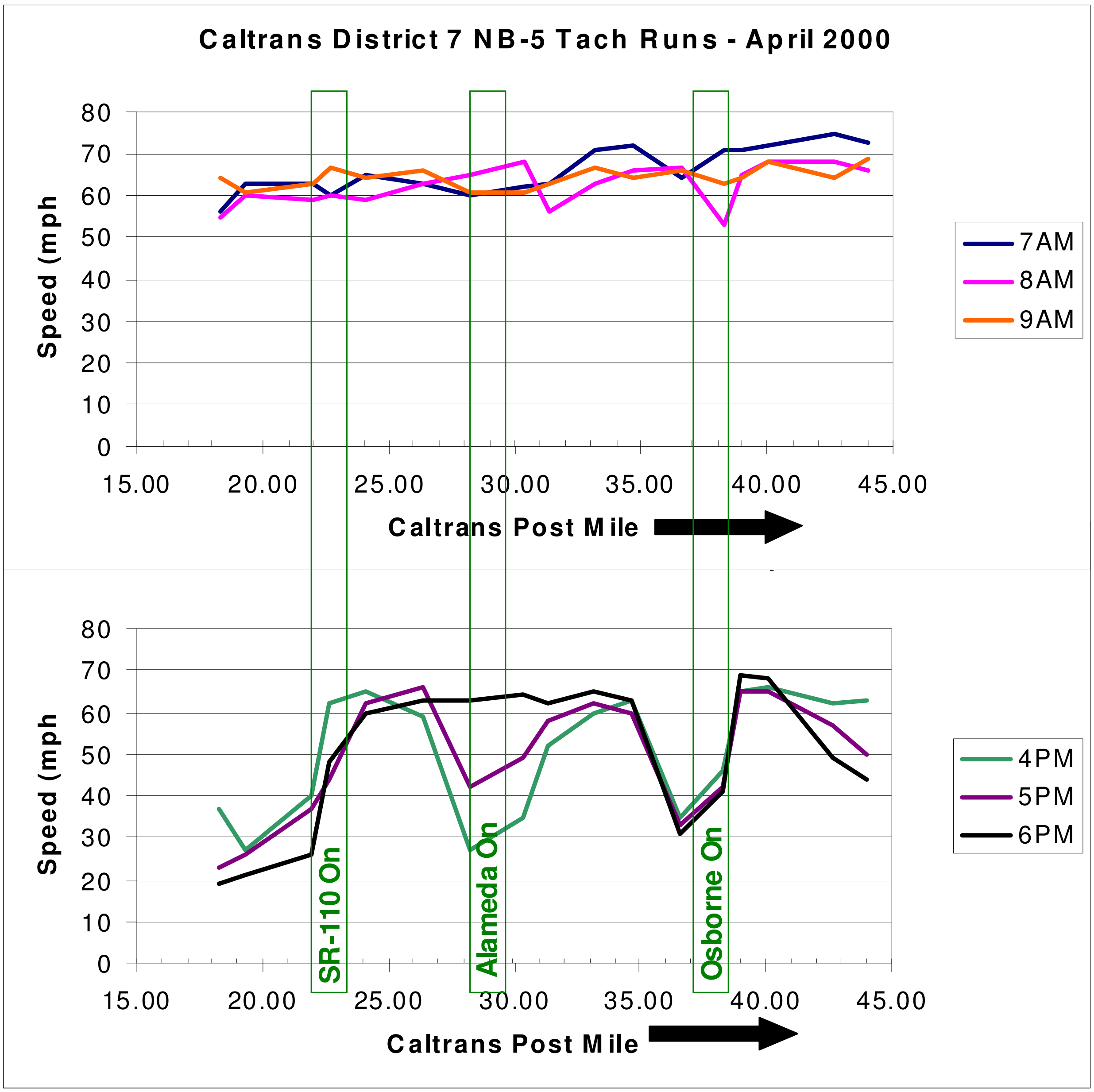
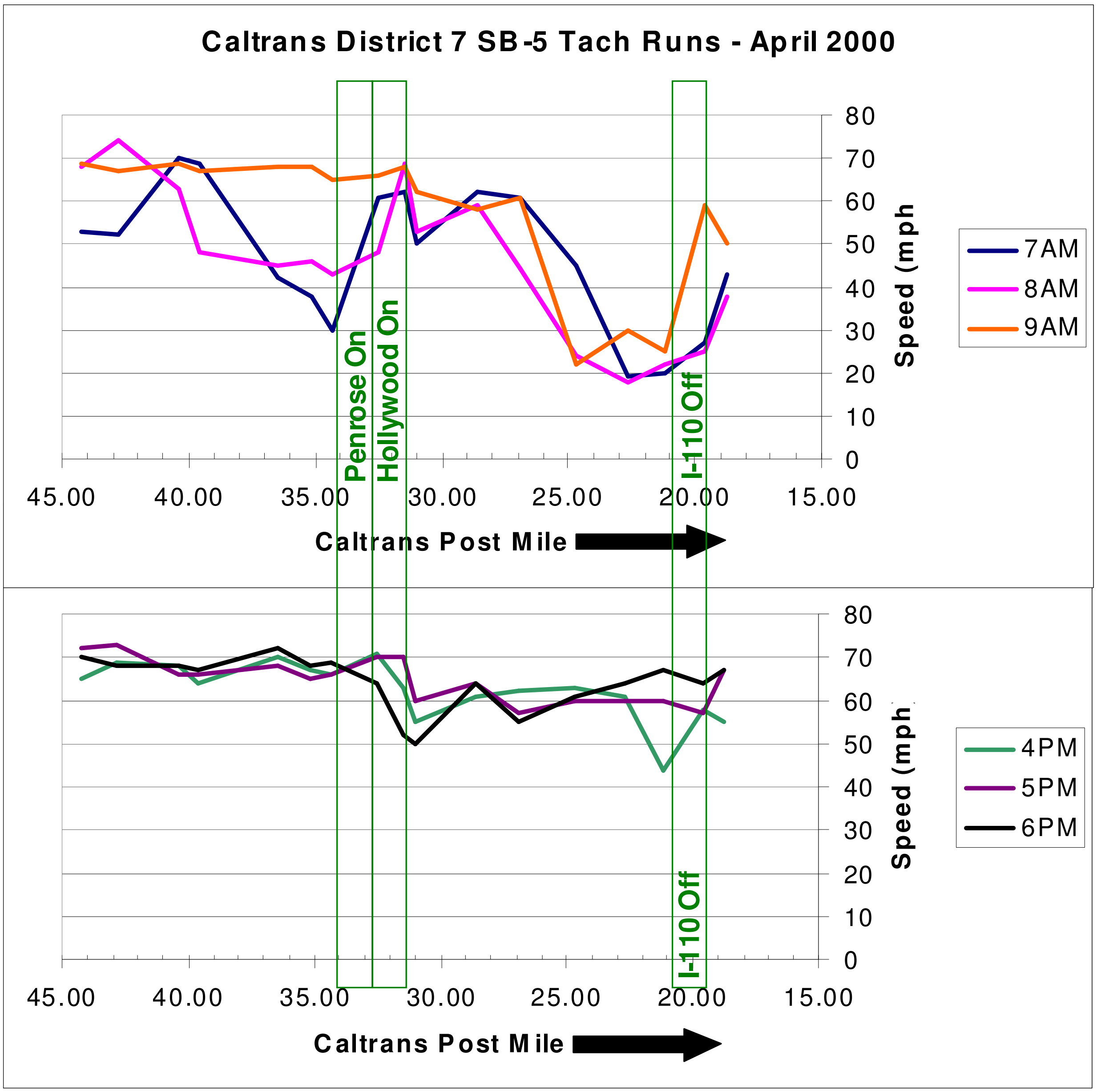


Exhibit 4A-7 shows the I-5 southbound probe vehicle runs, which were conducted on separated days in April 2000, for six specific times: 7:00 AM, 8:00 AM, 9:00 AM, 4:00 PM, 5:00 PM, and 6:00 PM. Slow speeds (congestion) and bottlenecks evident primarily in the AM peak hours near the I-110 off-ramp.

Exhibit 4A-7: Southbound I-5 Sample Probe Vehicle Runs (April 2000)



Automatic Detector Data

The third source used to identify potential bottlenecks prior to the in-depth field visits was to review speed contour and speed profile plots from automatic detectors. The study team downloaded detector data from the Caltrans Performance Measurement System (PeMS) to conduct this analysis.

Speed contour plots show speeds for every detector location for every five-minute period throughout the day. The resulting plot shows the location, extent, and duration of congestion.

Speed profile plots are very similar to probe vehicle graphs. Unlike the probe vehicle runs, each speed plot has the same time across the corridor. For example, an 8:00 AM plot includes the speed at one end of the corridor at 8:00 AM and the speed at the other end of the corridor also at 8:00 AM. With probe vehicle runs, the end time, or time at the end of the corridor is the departure time plus the actual travel time. Despite this difference, the two sets of graphs identify similar problem areas. These speed plots are then compiled at five minute intervals and presented in speed contour plots.

Northbound I-5 Detector Analysis

Exhibit 4A-8 shows the speed contour plots for Wednesday, October 24, 2007 and Thursday, October 25, 2007. The speed contour plots represent a typical weekday sample to illustrate the bottleneck locations and the resulting congestion. The sample days had observed or "good" detection data of less than 50 percent, providing less than desirable results with significant gaps. Still, some reasonable conclusions can be drawn from the results. Extensive field observation and/or additional data analysis is needed for the comprehensive assessment to verify the bottleneck locations and their causes.

The speed contour plots are typical speed contour diagrams for the I-5 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the I-10 to the I-210 interchange. The various colors indicate the average speeds corresponding to the color speed chart shown below the diagram. The dark blue blotches represent congested areas where speeds are reduced. The end of each dark blotch represents a bottleneck area, where speeds pickup after congestion, typically to 30 to 50 miles per hour in a relatively short distance. The horizontal length of each plot is the congested segment or queue lengths. The vertical length is the congested time period.

Exhibit 4A-8: Northbound I-5 Speed Contour Plots (October 2007)

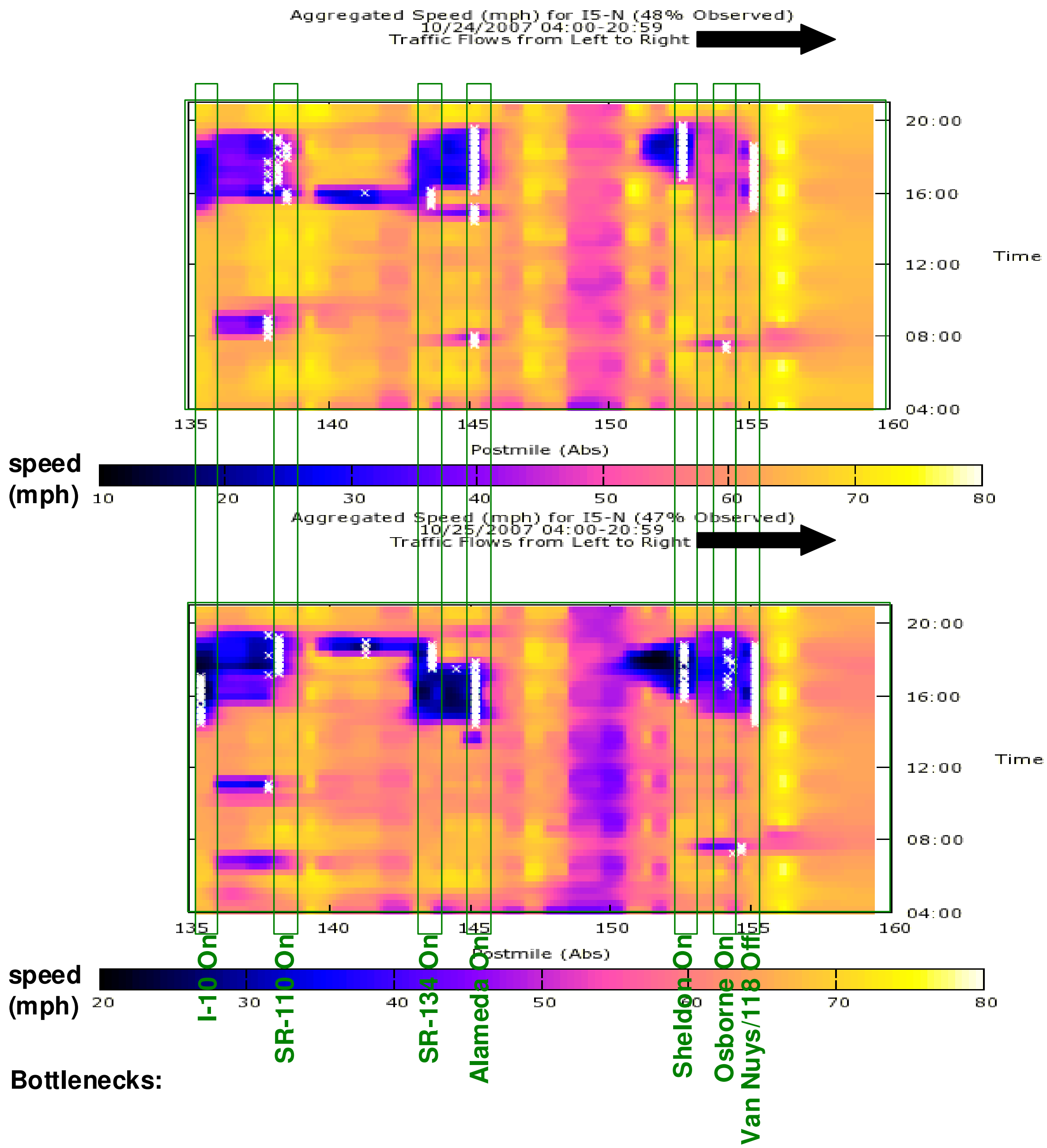
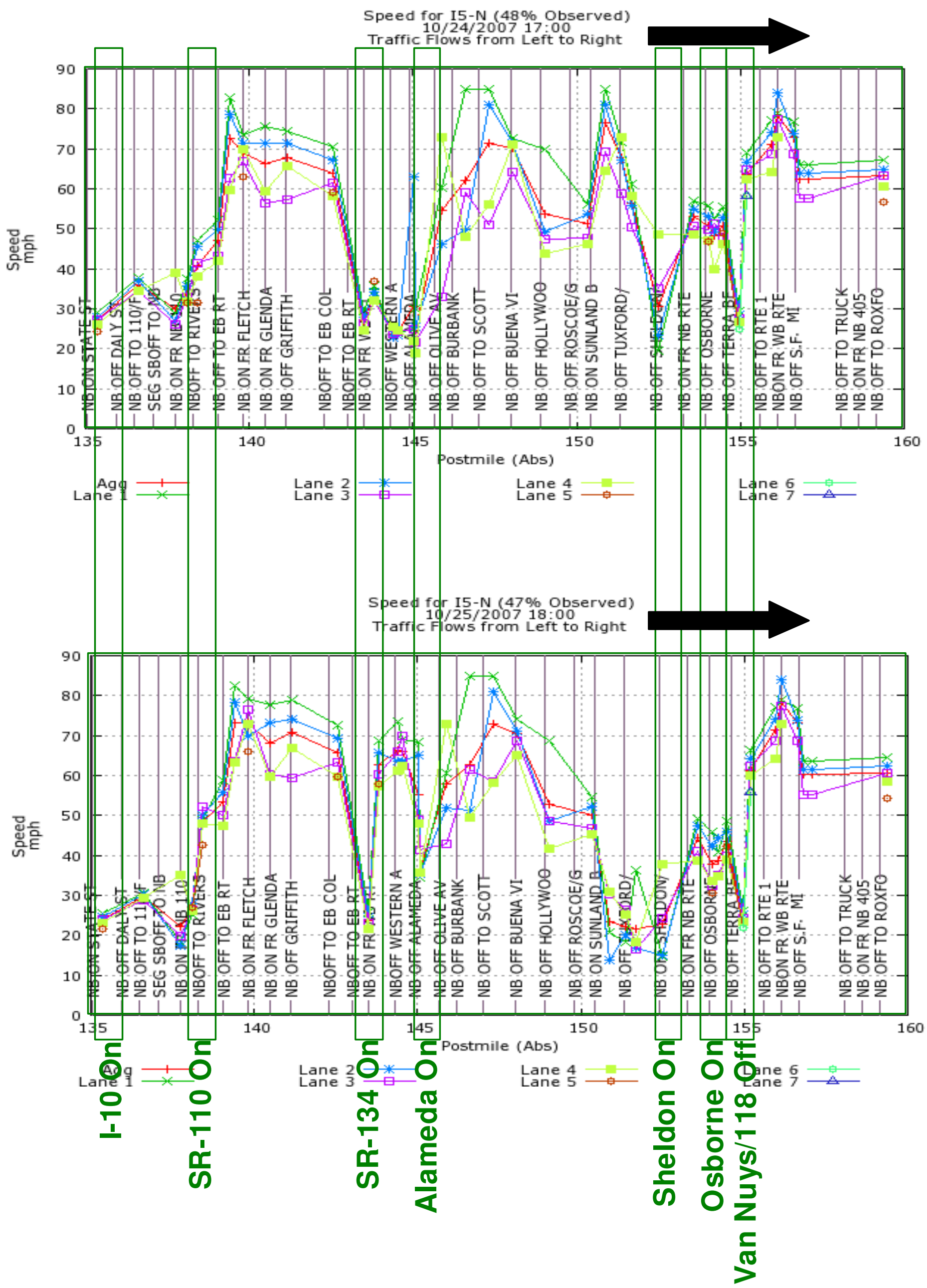


Exhibit 4A-9 shows the speed profile plots for Wednesday, October 24, 2007 at 5:00 PM and Thursday, October 25, 2007 at 6:00 PM in the evening. The speed profile plots represent a typical weekday sample to illustrate the bottleneck locations and congestion formed from them at a particular time in the day, in this case at 5:00 PM and 6:00 PM.

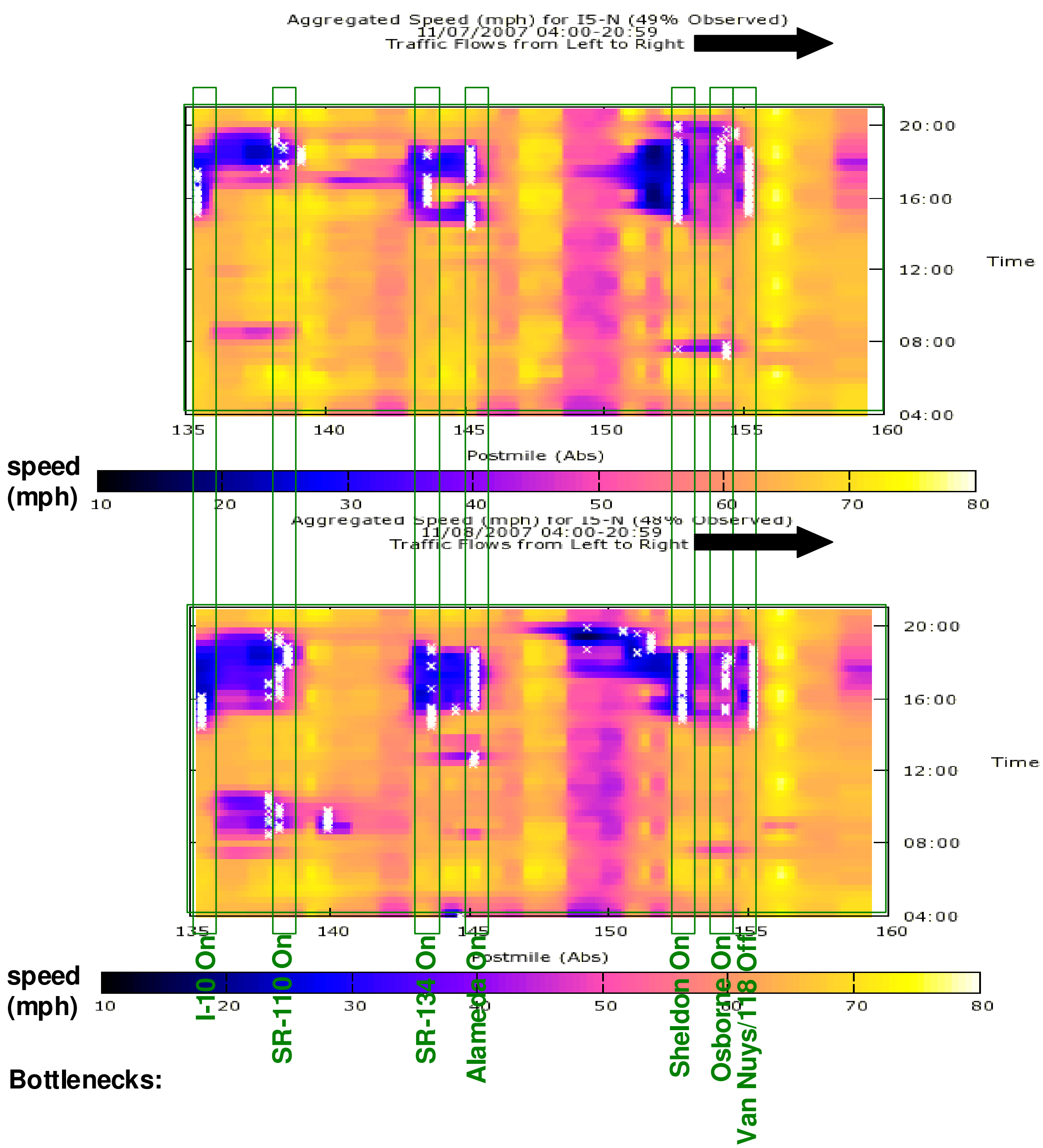
The speed profile plots illustrate the typical speed profile diagram for the I-5 freeway in the northbound direction (traffic moving left to right on the plot).

Exhibit 4A-9: Northbound I-5 Speed Profile Plots (October 2007)



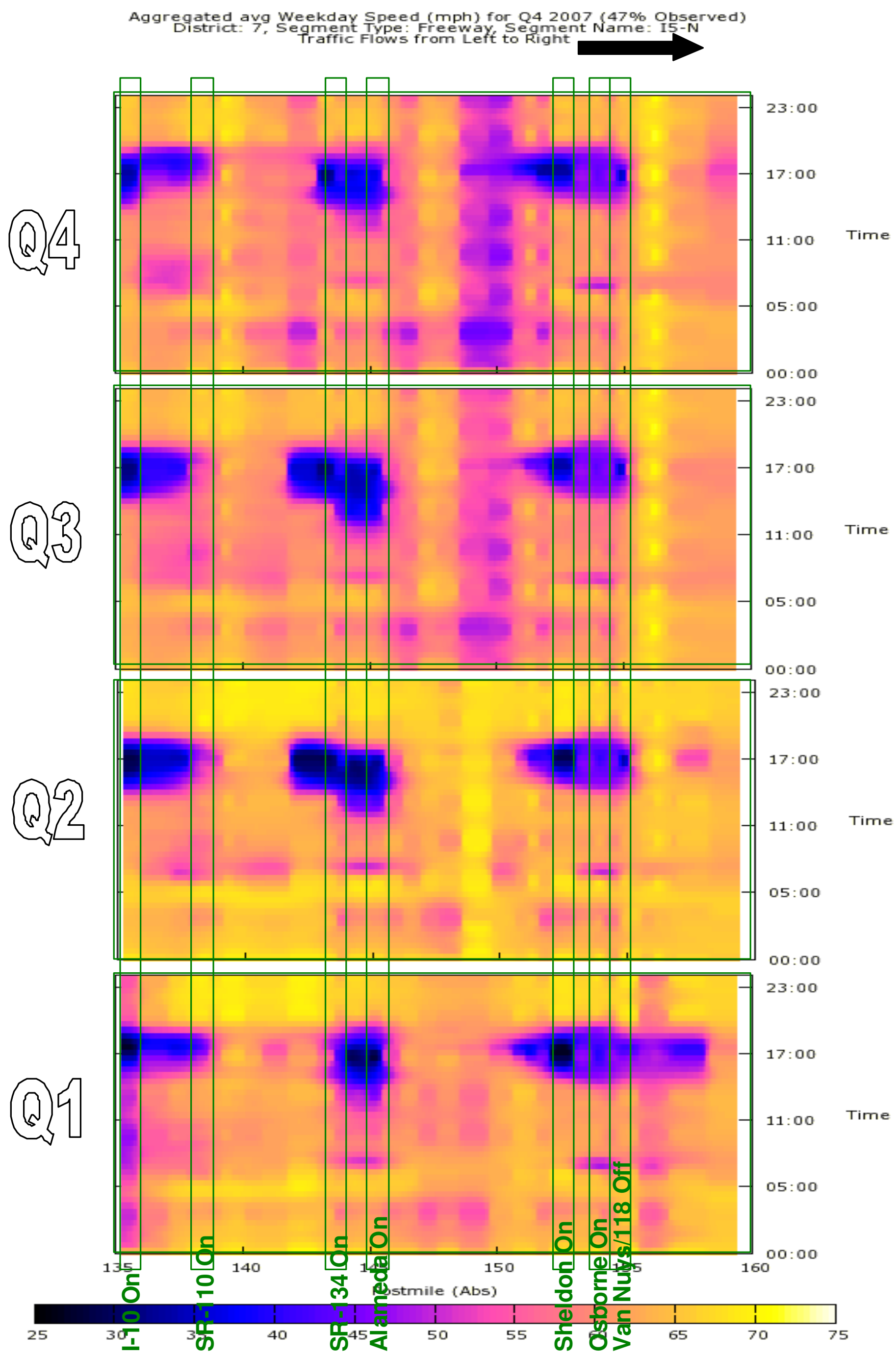
The study team selected additional days to examine and confirm the trends identified in the November sample days. Exhibit 4A-10 illustrates the speed contours of additional weekday samples in November 2007. The same bottleneck locations are identified on the new sample days, indicating a reoccurring pattern of the bottleneck locations.

Exhibit 4A-10: Northbound I-5 Speed Contour Plots (November 2007)



In addition to multiple days, averages over longer periods were also considered. Exhibit 4A-11 shows weekday averages by each quarter of 2007. Again, the same bottleneck locations are identified. From the long contours, the same bottlenecks are evident, further validating the reoccurring pattern of the bottleneck locations.

Exhibit 4A-11: Northbound I-5 Speed Long Contours (2007 Quarterly Averages)



Southbound I-5 Detector Analysis

Similarly, the study team analyzed speed contour and profile plots for sample days in October and November 2007 for the southbound direction. The results were validated by examining additional days in November 2007 and quarterly averages for 2007. Exhibits 4A-12 to Exhibit 4A-15 illustrate the speed contour and profile plots in the southbound direction (traffic moving left to right on the plot) for sample weekdays in October and November, additional typical weekdays in November, and 2007 quarterly weekday average long contours. Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the I-10 interchange to the I-210 interchange. Similar to the northbound speed contour analysis results, the southbound speed contour analysis results indicated reoccurring bottleneck locations across multiple weekdays and quarterly averages.

Exhibit 4A-12: Southbound I-5 Speed Contour Plots (October 2007)

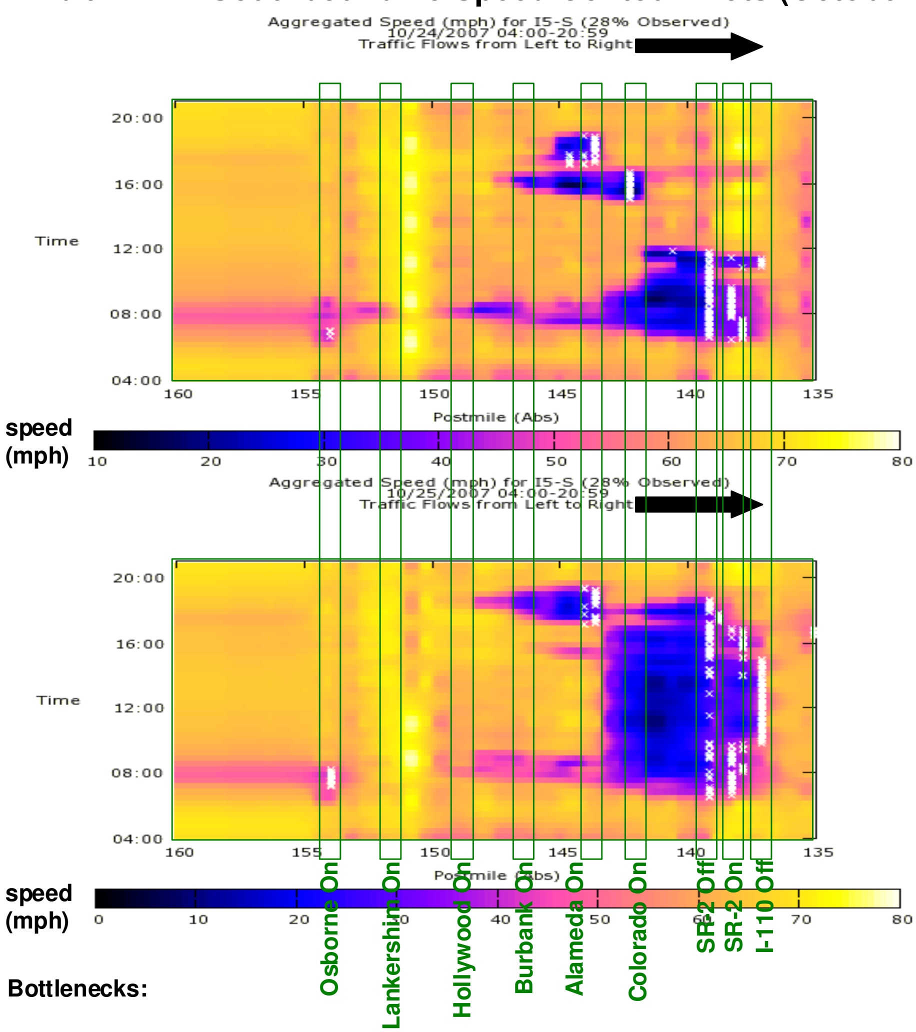


Exhibit 4A-13: Southbound I-5 Speed Profile Plots (Oct./Nov. 2007)

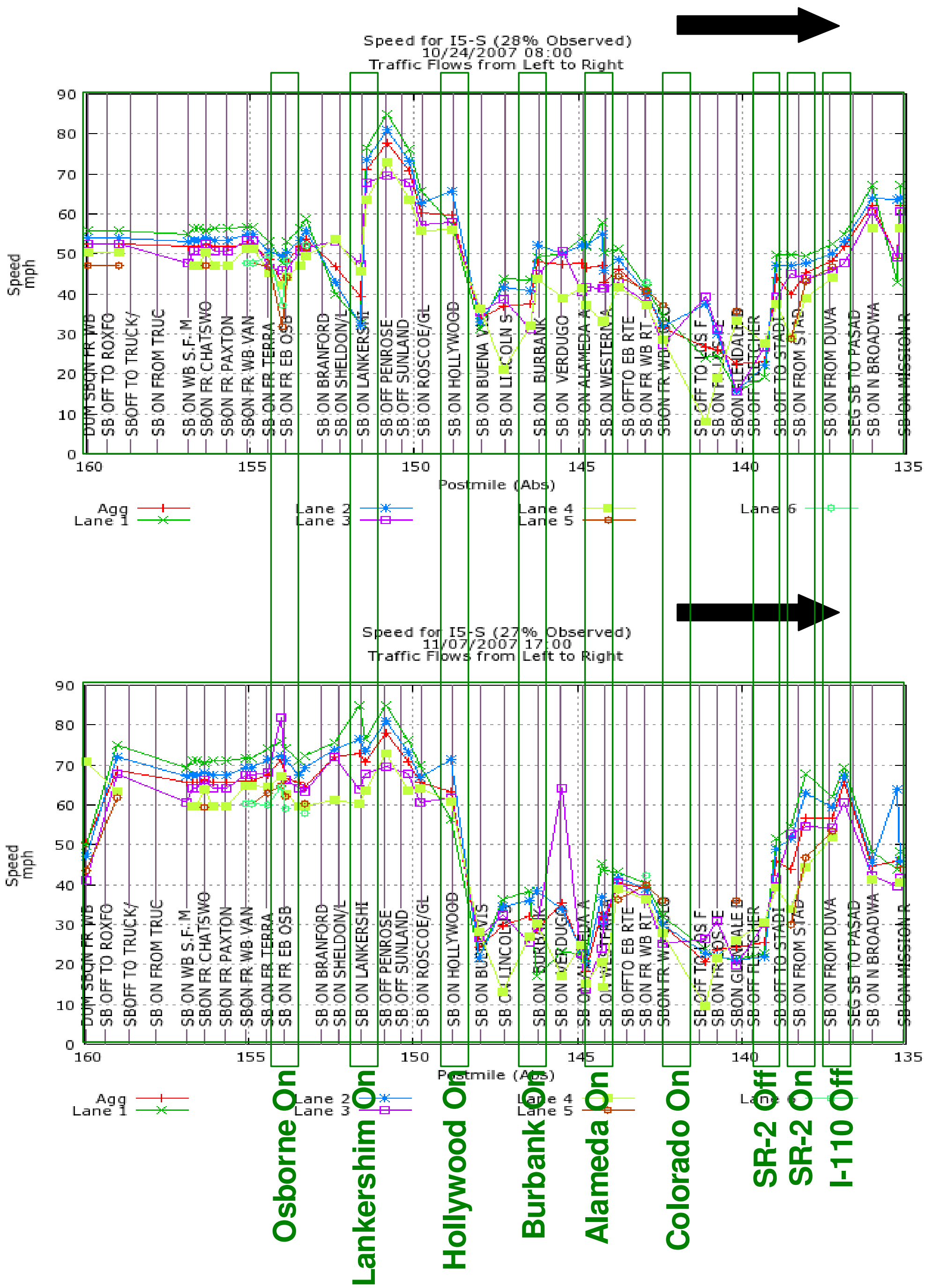


Exhibit 4A-14: Southbound I-5 Speed Contour Plots (November 2007)

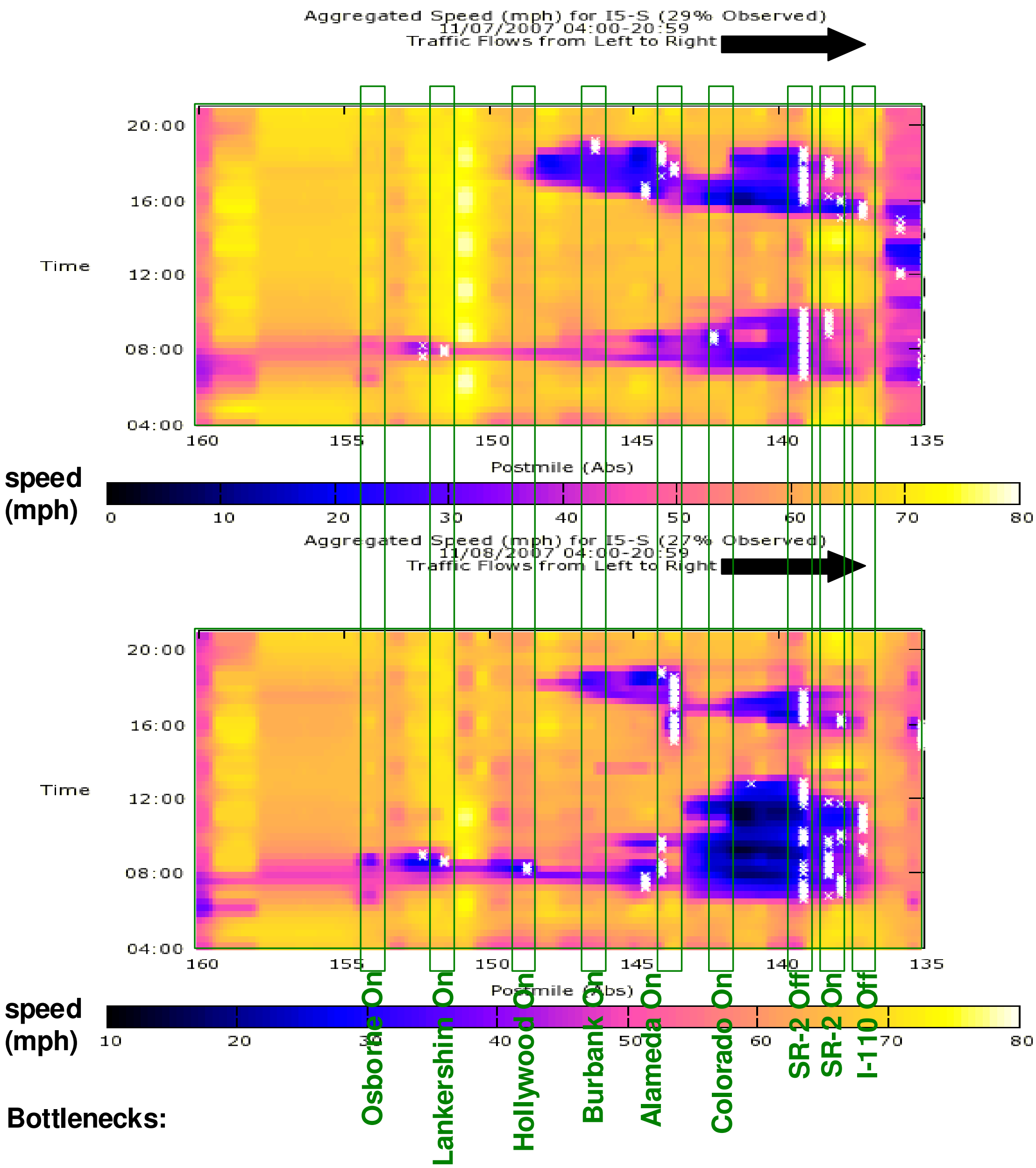
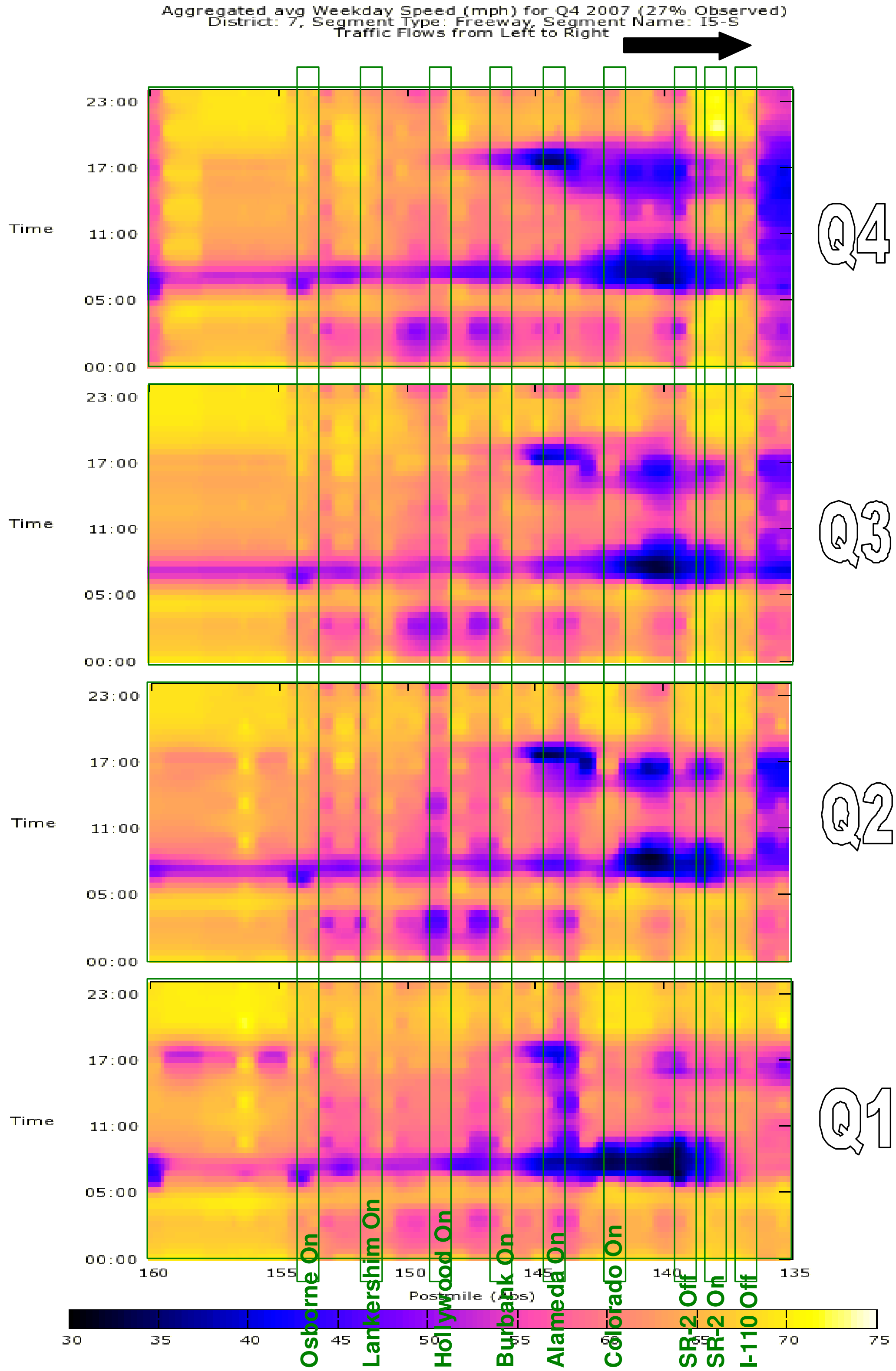


Exhibit 4A-15: Southbound I-5 Speed Long Contours (2007 Quarterly Averages)



B. Bottleneck Causality Analysis

The causes of each bottleneck location identified in the previous section are discussed in this part of the report.

Major bottlenecks are the location of corridor performance degradation and resulting congestion and lost productivity. It is important to verify the specific location and cause of each major bottleneck to determine appropriate solutions to traffic operational problems.

The location of each major bottleneck should be verified by multiple field observations on separate days. The cause of each major bottleneck can also identified by field observations and additional traffic data analysis. For the I-5 Corridor, field observations were conducted by the project consultant team on multiple days (midweek) in September, October, and November 2008 during the AM and PM peak hours. The most recent field reviews were conducted from November 18 to 20, 2008.

By definition, a bottleneck is a condition where traffic demand exceeds the capacity of the roadway facility. The cause of a bottleneck is typically related to a sudden reduction in capacity, such as a physical loss when a lane drop occurs or when heavy merging and weaving take place at major on and off-ramps. Other variables that can cause reductions in capacity include weather or driver distractions. On the demand side, surges in demand can be larger than a roadway can accommodate. In many cases, it is a combination of increased demand and capacity reductions.

NORTHBOUND BOTTLENECK CAUSALITY

Major northbound bottlenecks and congestion often occurs during both AM and PM peak hours. The following is a summary of the northbound bottlenecks and the identified causes.

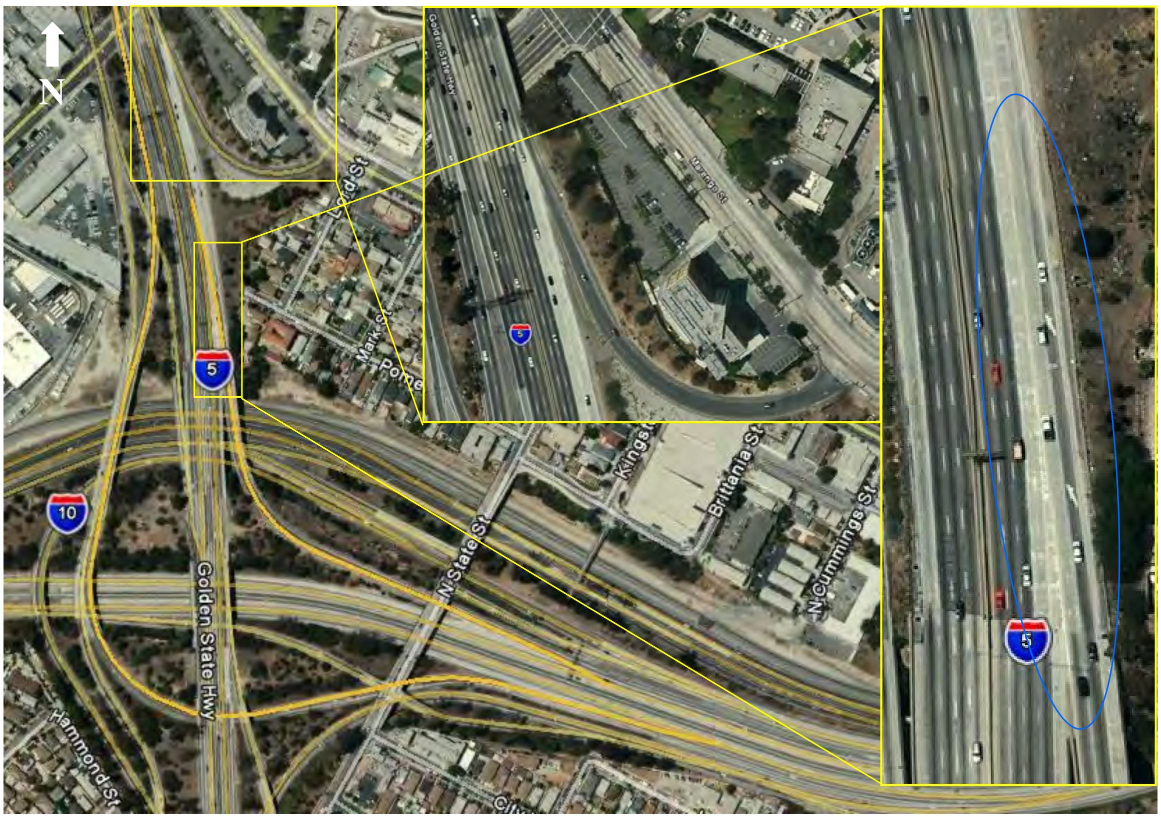
The following northbound bottlenecks were identified in the previous section:

- I-10 On-Ramp
- SR-110 On-Ramp
- SR-134 On-Ramp
- Alameda Avenue On-Ramp
- Sheldon Avenue On-Ramp
- Osborne Avenue On-Ramp
- SR-118 Off-Ramp.

I-10 On-Ramp

Exhibit 4B-1 is an aerial photograph of the northbound I-5 mainline at the I-10 connector on-ramp, which is the beginning of the study corridor. During the PM peak hours, the volume of traffic from I-10 is heavy. The northbound I-5 cannot accommodate this additional demand and results in considerable congestion. Another on-ramp from Marengo Street adds to the I-10 merging traffic less than 1,000 feet away. Significant queuing results on the I-10 connector as well to the I-10 mainline.

Exhibit 4B-1: Northbound I-5 at I-10 On-Ramp



SR-110 On-Ramp

Exhibit 4B-2 is an aerial photograph of the northbound I-5 mainline at the SR-110 connector on-ramp. As shown in the exhibit, significant merging occurs from the connector on-ramp to the I-5 mainline, causing the traffic stream to breakdown, resulting in congestion. The mainline traffic cannot accommodate the additional demand from the connector ramp. The new connector lane is soon lost to the SR-2 exit and vehicles often try to merge quickly onto the I-5 mainline. In addition, the SR-110 connector ramp is a two-lane ramp that merges into one as it reaches the I-5 mainline; as a result, some of the traffic on the left connector lane tries to merge into the I-5 mainline before the two connector lanes merge. With slow-moving vehicles entering the fast-moving I-5 mainline, the mainline traffic is forced to slow down. This creates a ripple effect and a bottleneck.

Although this condition occurs mostly during the PM peak hours, it also frequently occurs during the AM peak hours. This location is likely to be a significant bottleneck in both the AM and PM peak hours in the future.

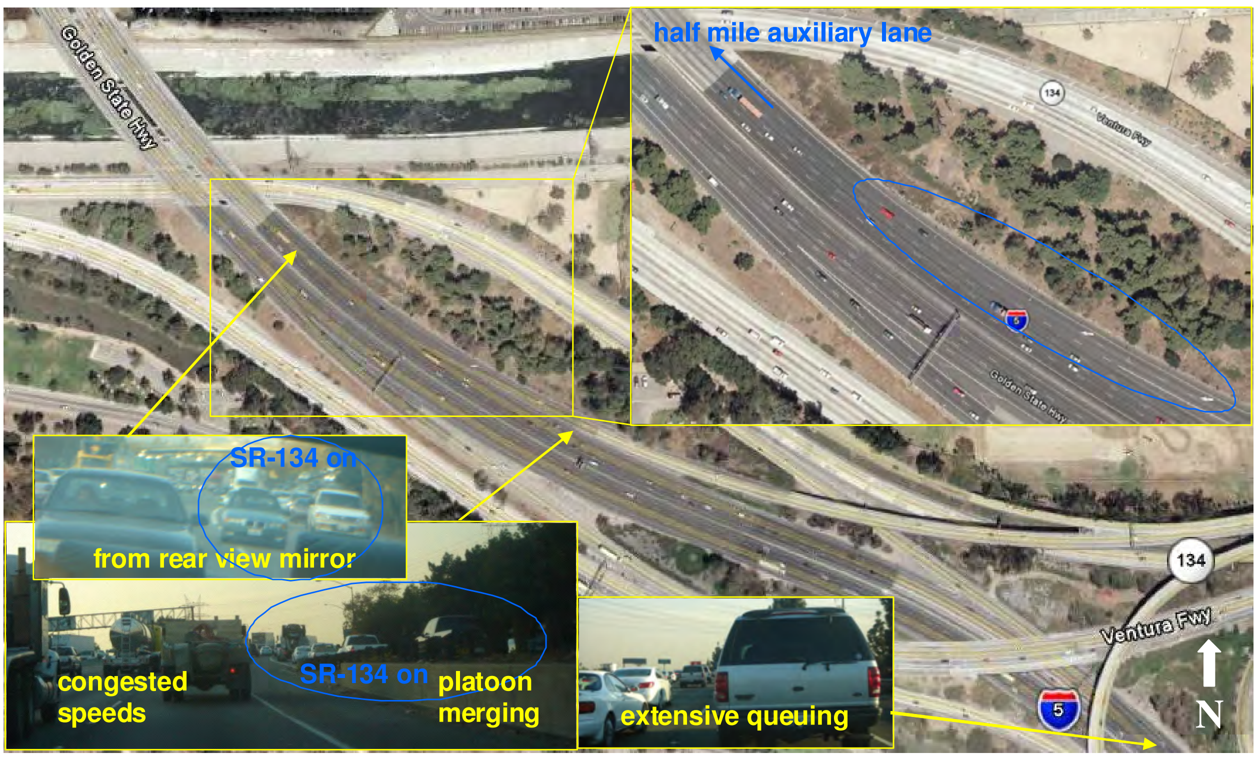
Exhibit 4B-2: Northbound I-5 at I-110 On-Ramp

SR-134 On-Ramp

Exhibit 4B-3 is an aerial photograph of the northbound I-5 mainline at the SR-134 connector on-ramp. As with the I-10 on-ramp and the SR-110 on-ramp, the I-5 mainline cannot accommodate the surge in demand from the SR-134 connector on-ramp. The lower right inset photograph shows significant stop-and-go congestion approaching this location. The other two photographs show the substantial platoon traffic from the SR-134 connector merging onto the I-5 mainline.

While the demand is above what the facility capacity can handle, the capacity is also likely to be impacted by an uphill grade and a roadway curve to the right while traffic merges to the left.

Exhibit 4B-3: Northbound I-5 at SR-134 On-Ramp



Alameda Avenue On-Ramp

Exhibit 4B-4 is an aerial photograph of the northbound I-5 at the Alameda Avenue interchange. The bottleneck condition at this location is caused by platoons of vehicles merging onto the freeway right as the mainline traffic makes the turn. The photograph illustrates the mainline queuing behind the merge point and free flow condition past it.

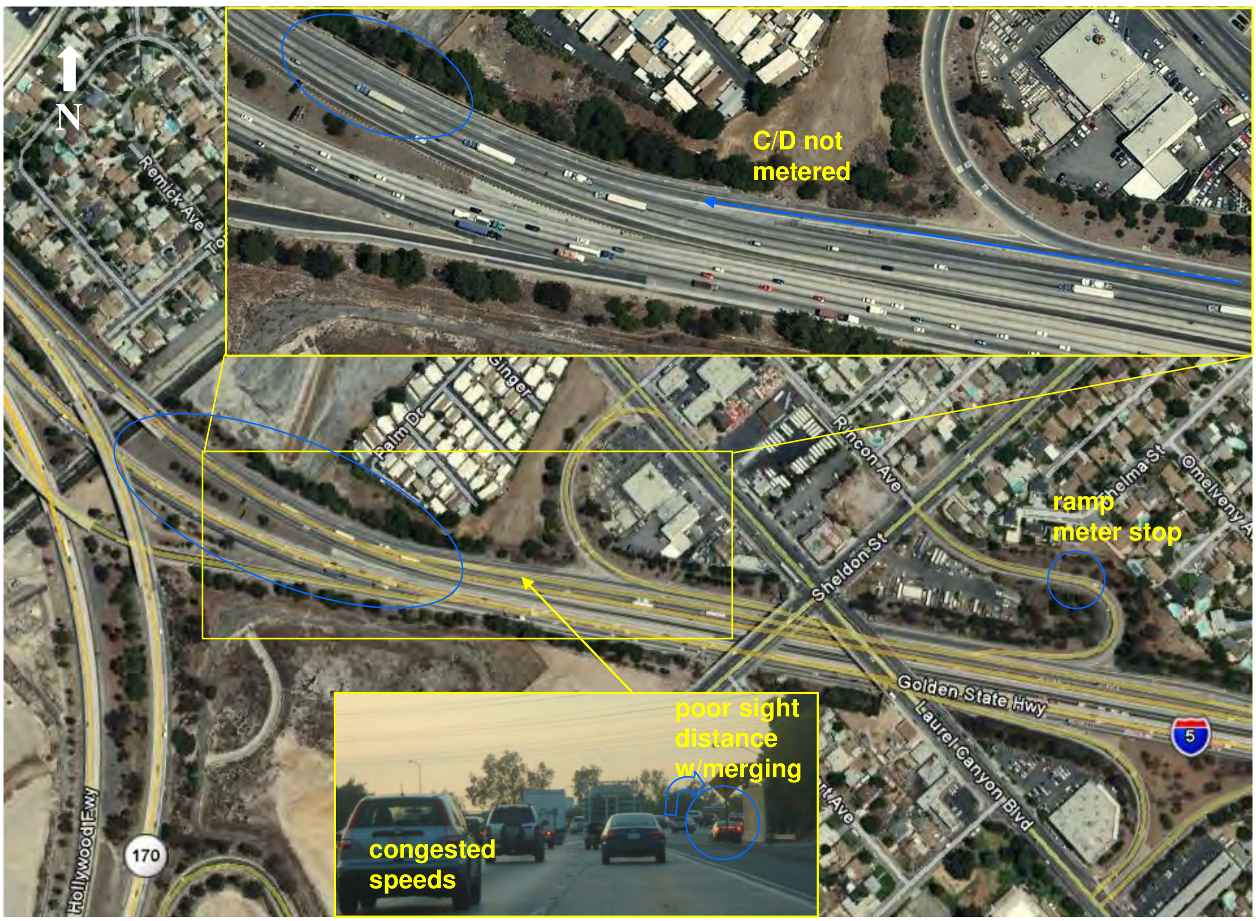
While the westbound Alameda Avenue on-ramp is metered, the eastbound Alameda Avenue on-ramp and the collector-distributor are not, which causes vehicles to platoon. This location is also impacted by the roadway curve to the right and uphill grade over San Fernando Road.

Exhibit 4B-4: Northbound I-5 at Alameda Avenue On-Ramp

Sheldon Street On-Ramp

Exhibit 4B-5 is an aerial photograph of the northbound I-5 at the Sheldon Street on-ramp. The bottleneck condition at this location is caused by the combination of uphill grade, roadway curvature, and traffic merging in from the Sheldon Street on-ramp. Sheldon Street traffic is metered, but too far back on the ramp to be effective. The location of the metering is illustrated by the blue circle in the exhibit. In addition, the collector-distributor traffic is not metered, which results in occasional platoons of merging vehicles.

Exhibit 4B-5: Northbound I-5 at Sheldon Street On-Ramp



SR-170 On/Osborne Street Off-Ramp

Exhibit 4B-6 is an aerial photograph of the northbound I-5 at the SR-170 on-ramp and Osborne Street off-ramp. As the exhibit illustrates, considerable merging (and cross weaving) occurs between the SR-170 connector on-ramp and the Osborne Street off-ramp. The outermost lane from the I-5 mainline is dropped at the Osborne Street interchange, forcing the mainline traffic to merge left, while at the same time, the SR-170 traffic enters the I-5 mainline from the left. Merges on both sides of the freeway cause the middle lanes to slow. This results in bottleneck conditions.

Exhibit 4B-6: Northbound I-5 at SR-170 On/Osborne Street Off-Ramp

SR-118 Off-Ramp

Exhibit 4B-7 is an aerial photograph of the northbound I-5 at the SR-118 off-ramp. As the exhibit illustrates, the seven lanes from the I-5 mainline is reduced to four as three lanes go to the SR-118 connector exit. When the mainline volumes are high, this reduction in lanes cannot accommodate the volume of demand resulting in the bottleneck condition.

Exhibit 4B-7: Northbound I-5 at SR-118 Off-Ramp

SOUTHBOUND BOTTLENECK CAUSALITY

The southbound bottlenecks and congestion occur mostly in the AM peak hours, although evidence of some of the same bottlenecks to a lesser degree can be found in the PM peak hours. The southbound bottlenecks were identified at:

- SR-118 On-Ramp
- SR-170 On-Ramp
- SR-134 On-Ramp
- SR-2 Off-Ramp
- SR-2 On-Ramp
- SR-110 Off-Ramp

The following is a summary of the southbound bottlenecks and identified causes.

SR-118 On-Ramp

Exhibit 4B-8 is an aerial photograph of the southbound I-5 mainline at the SR-118 connector on-ramp. Although this location was not identified as a major bottleneck, congestion caused by traffic entering from the SR-118 connector on-ramp was observed during numerous site visits. The SR-118 traffic enters on new lanes, but the traffic is forced to merge left when the right lanes exit to the SR-170 further downstream. This causes an occasional bottleneck at this location.

Exhibit 4B-8: Southbound I-5 at SR-118

SR-170 Off-Ramp

Exhibit 4B-9 is an aerial photograph of the southbound I-5 mainline at the SR-170 connector off-ramp. This is a major bottleneck location, shown in the inset photograph. Traffic demand for the SR-170 is very high, creating a backup onto the I-5 mainline. As a result, the I-5 mainline traffic shifts left to avoid the backup and creates further merging and queuing.

Exhibit 4B-9: Southbound I-5 at SR-170 Off-Ramp

SR-134 Off-Ramp

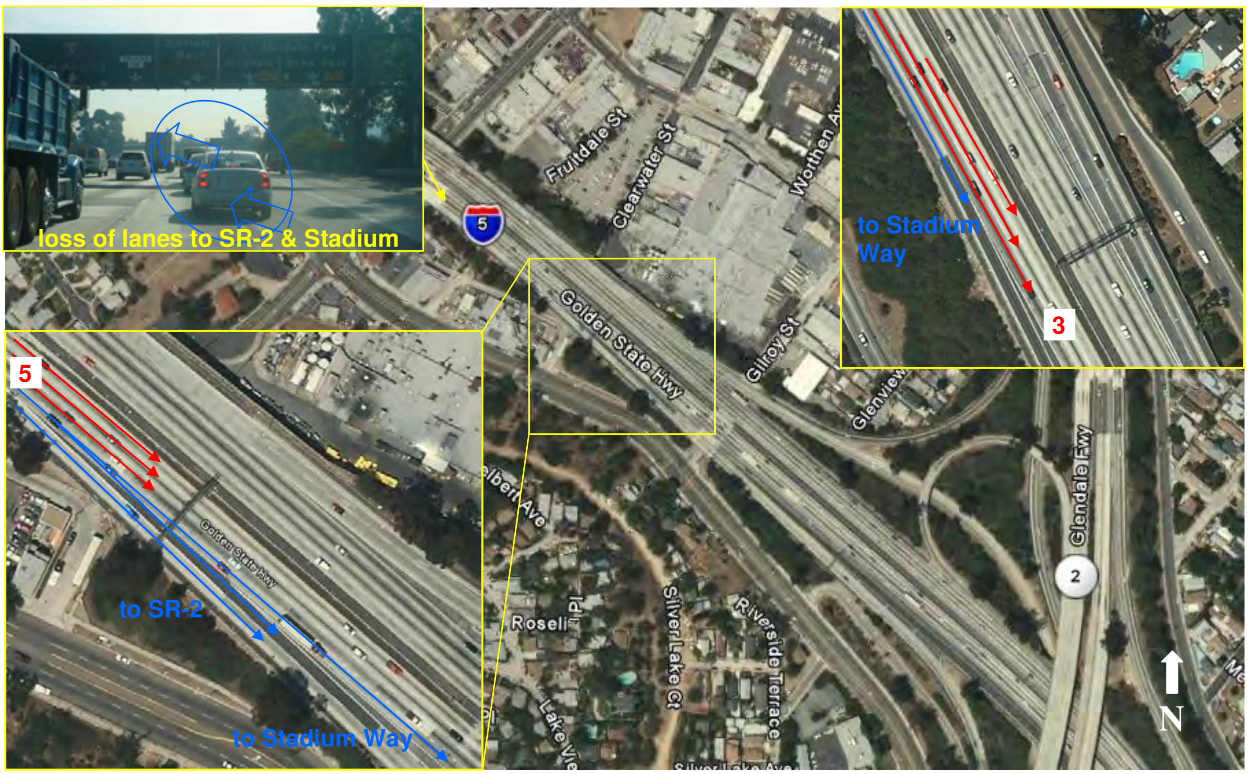
Exhibit 4B-10 is an aerial photograph of the southbound I-5 at the SR-134 connector off-ramp. As the exhibit illustrates, traffic exiting to the SR-134 often queues onto the I-5 mainline, causing a bottleneck at this location. Congestion occurs mostly during PM peak hours (when demand for the SR-134 connector is high) and seldom during AM peak hours.

Exhibit 4B-10: Southbound I-5 at SR-134 Off-Ramp

SR-2 Off-Ramp

Exhibit 4B-11 is an aerial photograph of the southbound I-5 at the SR-2 connector off-ramp. The mainline roadway loses one lane to the SR-2 exit, going from five lanes to four, and loses another lane at Stadium Way. As the inset photograph illustrates, the demand for SR-2 is not significant. However, the two lane drops cause the traffic in those outer lanes to move left, causing a squeeze on those left lanes, resulting in a bottleneck condition.

Exhibit 4B-11: Southbound I-5 at SR-2 Off-Ramp



SR-2 On-Ramp

Exhibit 4B-12 is an aerial photograph of the southbound I-5 mainline at SR-2 connector on-ramp. As shown in the inset photograph, there is a surge of demand from the SR-2 connector on-ramp, particularly during the AM peak hours, resulting in a steady stream of platoon traffic merging onto the I-5 mainline freeway.

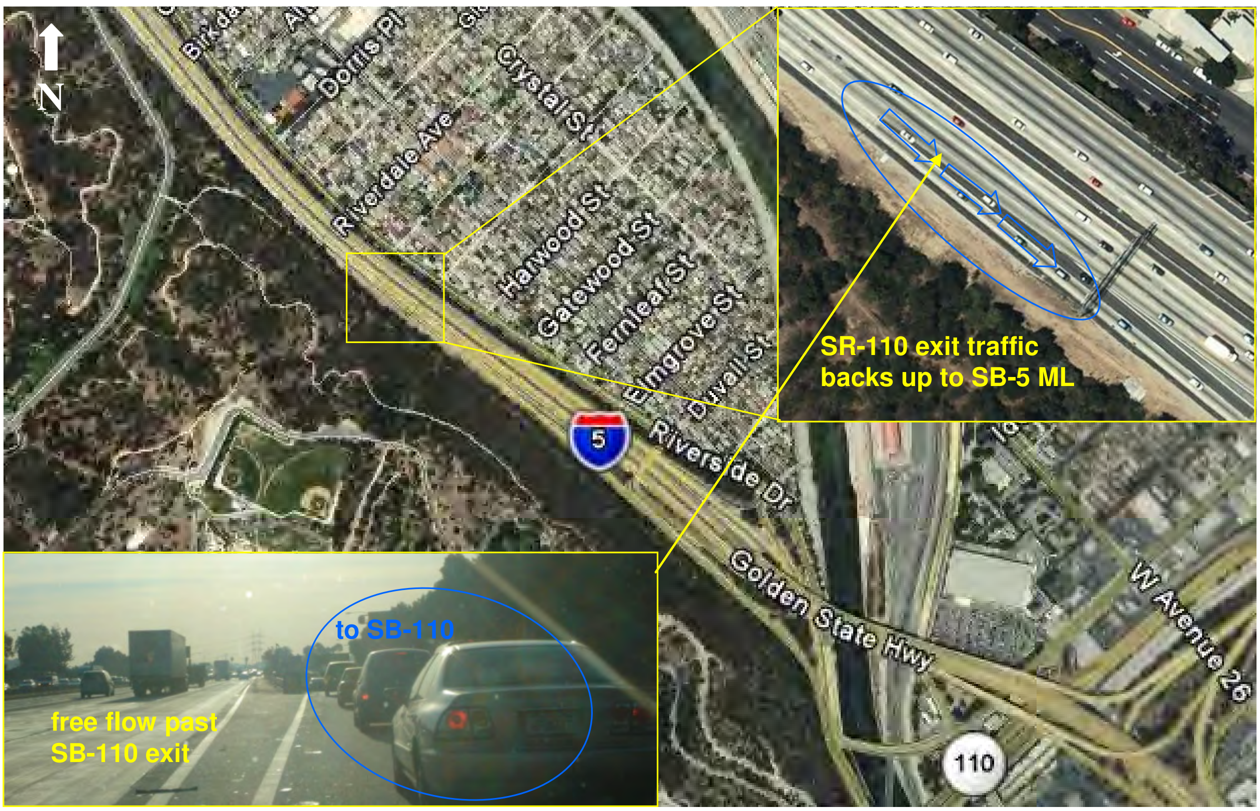
Although this on-ramp traffic enters into new lanes, they must move left to continue onto I-5. The outer lanes exit to the SR-110 exit further downstream.

Exhibit 4B-12: Southbound I-5 at SR-2 On-Ramp

SR-110 Off-Ramp

Exhibit 4B-13 is an aerial photograph of the southbound I-5 mainline at the southbound SR-110 connector off-ramp. This is the most significant bottleneck in the southbound direction. This bottleneck and congestion occurs often from 7 AM to 7 PM. Traffic exiting to the southbound SR-110 connector is destined to or passing through the Los Angeles downtown area. The bottleneck condition is caused by the exit traffic backing onto the I-5 mainline blocking the I-5 through traffic lanes and the SR-2 connector on-ramp traffic merging to the left lanes. There is inadequate capacity to accommodate the demand due to the blockage of the through lanes by the exit traffic. As the inset photograph illustrates, free-flow conditions are restored just past this bottleneck location.

Exhibit 4B-13: Southbound I-5 at SR-110 Off-Ramp



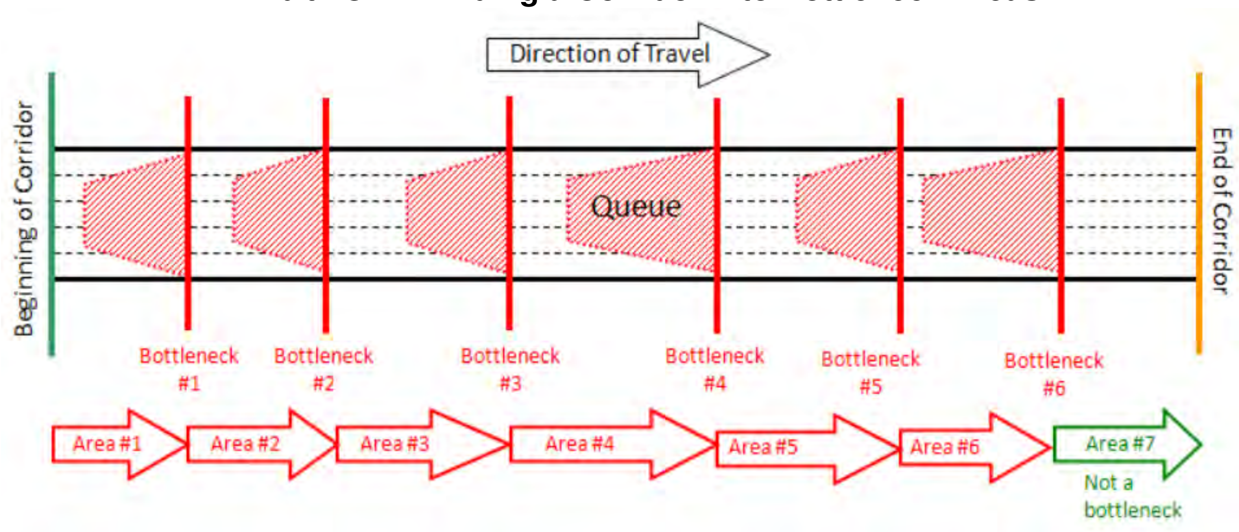
C. Bottleneck Area Analysis

Once the bottlenecks were identified, the corridor is divided into “bottleneck areas.” Bottleneck areas represent segments that are defined by one major bottleneck (or a number of smaller ones). By segmenting the corridors into such bottleneck areas, some performance statistics that were presented earlier for the entire corridor can be segmented by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. The performance statistics that lend themselves to such segmentation include:

- Delay
- Productivity
- Safety.

The analysis of bottleneck areas is based on 2007 data (when available), the base year of the model. Based on this segmentation approach, the study corridor comprises several bottleneck areas, which differ by direction. Exhibit 4C-1 illustrates the general concept of bottleneck areas. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas.

Exhibit 4C-1: Dividing a Corridor into Bottleneck Areas



Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. Based on the above, the bottlenecks previously identified in Exhibit 4A-1 are shown again in Exhibits 4C-2 and 4C-3 with the associated bottleneck areas.

Exhibit 4C-2: Northbound I-5 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
SR-110 On	From I-10 to SR-110 On	✓	✓	135.0	18.4	138.0	21.3	3.0
SR-134 On	From SR-110 On to SR-134 On		✓	138.0	21.3	143.5	26.8	5.5
Alameda On	From SR-134 On to Alameda On		✓	143.5	26.8	145.2	28.6	1.7
Sheldon On	From Alameda On to Sheldon On		✓	145.2	28.6	152.7	36.1	7.5
Osborne Off	From Sheldon On to Osborne Off	✓	✓	152.7	36.1	153.9	37.2	1.2
SR-118 Off	From Osborne Off to SR-118 Off		✓	153.9	37.2	155.6	38.9	1.7
N/A	From SR-118 Off to I-210	N/A		155.6	38.9	162.5	44.0	6.9

Exhibit 4C-3: Southbound I-5 Identified Bottleneck Areas

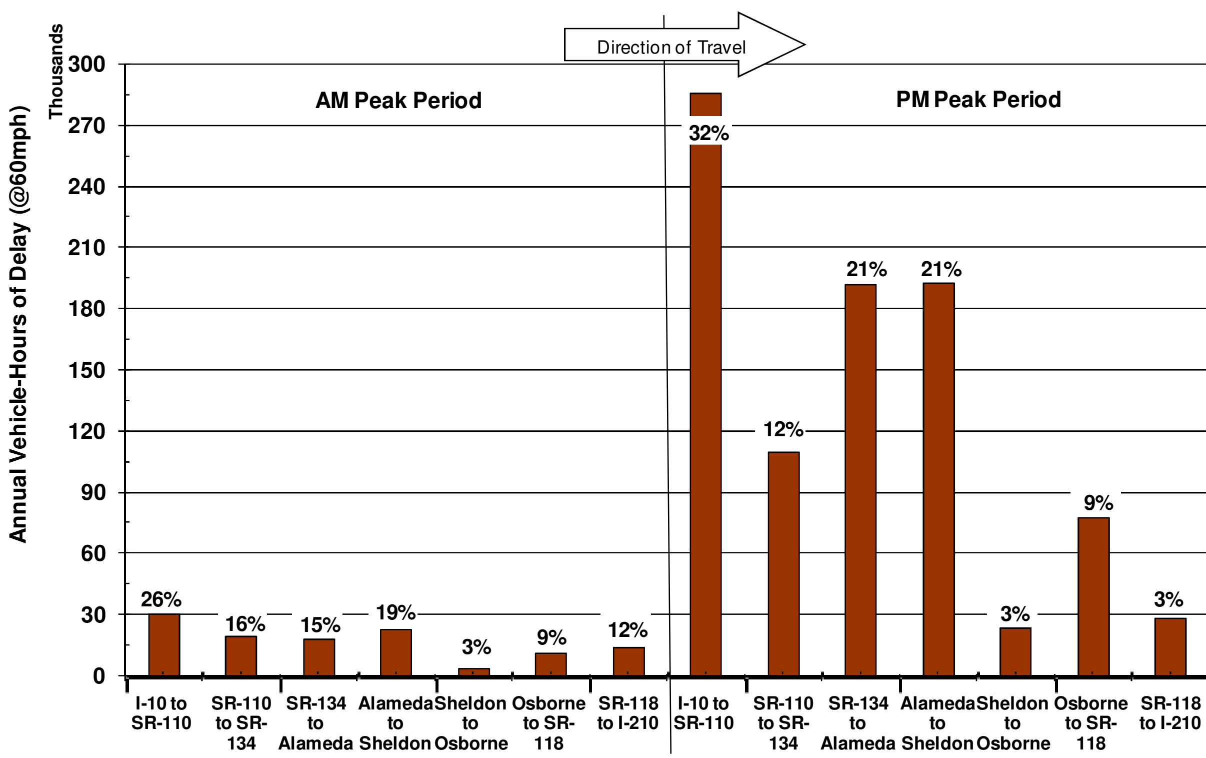
Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
SR-118 On	From I-210 to SR-118 On	✓		162.5	44.0	155.5	38.9	7.0
SR-170 Off	From SR-118 On to SR-170 Off	✓		155.5	38.9	153.0	36.4	2.5
SR-134 Off	From SR-170 Off to SR-134 Off		✓	153.0	36.4	143.5	26.9	9.5
SR-2 Off	From SR-134 Off to SR-2 Off	✓	✓	143.5	26.9	139.3	22.7	4.2
SR-2 On	From SR-2 Off to SR-2 On	✓	✓	139.3	22.7	138.5	21.9	0.8
I-110 Off	From SR-2 On to SR-110 Off	✓	✓	138.5	21.9	137.6	21.0	0.9
N/A	From SR-110 Off to I-10	N/A		137.6	21.0	135.0	18.4	2.6

MOBILITY BY BOTTLENECK AREA

Mobility describes how efficiently the corridor moves vehicles. To evaluate how well (or poorly) each bottleneck area moves vehicles, vehicle-hours of delay were calculated for each segment. The results reveal the areas of the corridor that experience the worst mobility.

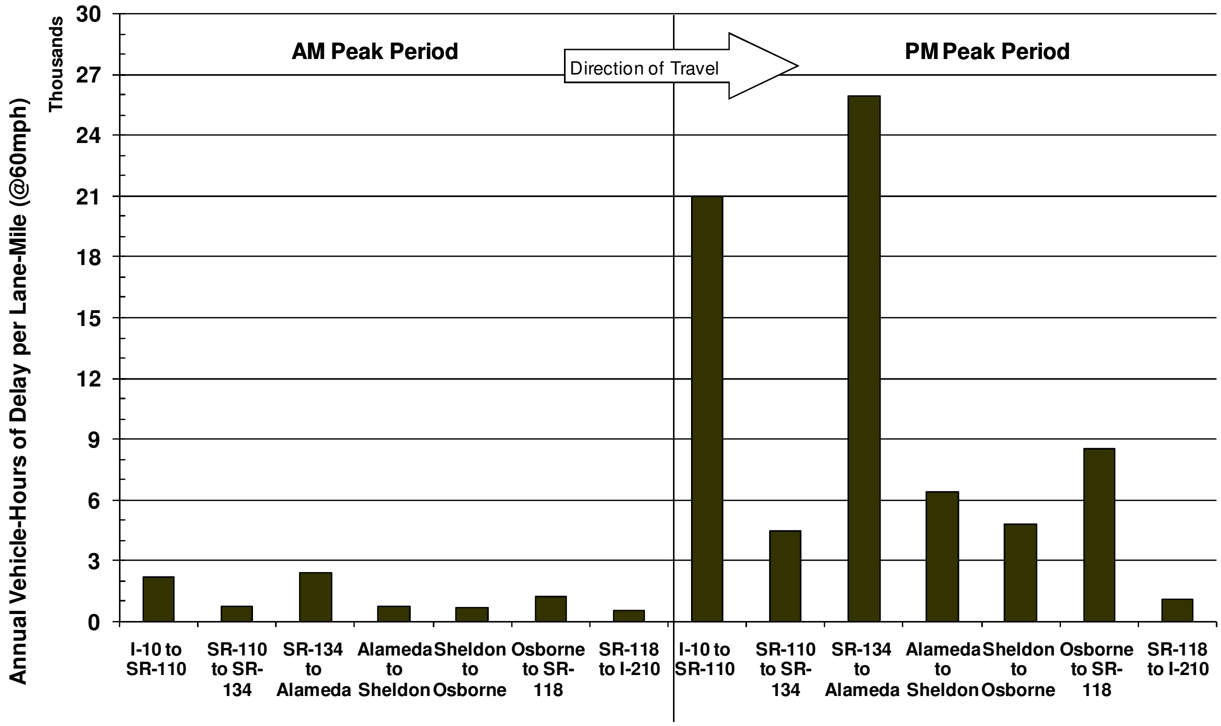
Exhibits 4C-4 and 4C-6 illustrate the vehicle-hours of delay experienced by each bottleneck area. As depicted in Exhibit 4C-4, delay in the northbound direction is concentrated in the PM peak with almost eight times more total delay than the AM peak. The segment between the I-10 and SR-110 experienced the greatest delay during both AM and PM peaks with 32 and 26 percent of the delay on the corridor. During the PM peak, the segments from SR-134 to Alameda and Alameda to Sheldon also experienced high levels of delay at just under 200,000 annual vehicle-hours of delay each, or 21 percent of the delay on the corridor. Unlike the northbound direction, delay in the southbound direction is spread more evenly between peak periods. Exhibit 4C-6 shows that the segment between SR-134 to SR-2 experienced the greatest delay with 36 and 39 percent of the delay on the corridor during the AM and PM peak periods.

Exhibit 4C-4: Northbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: Caltrans detector data

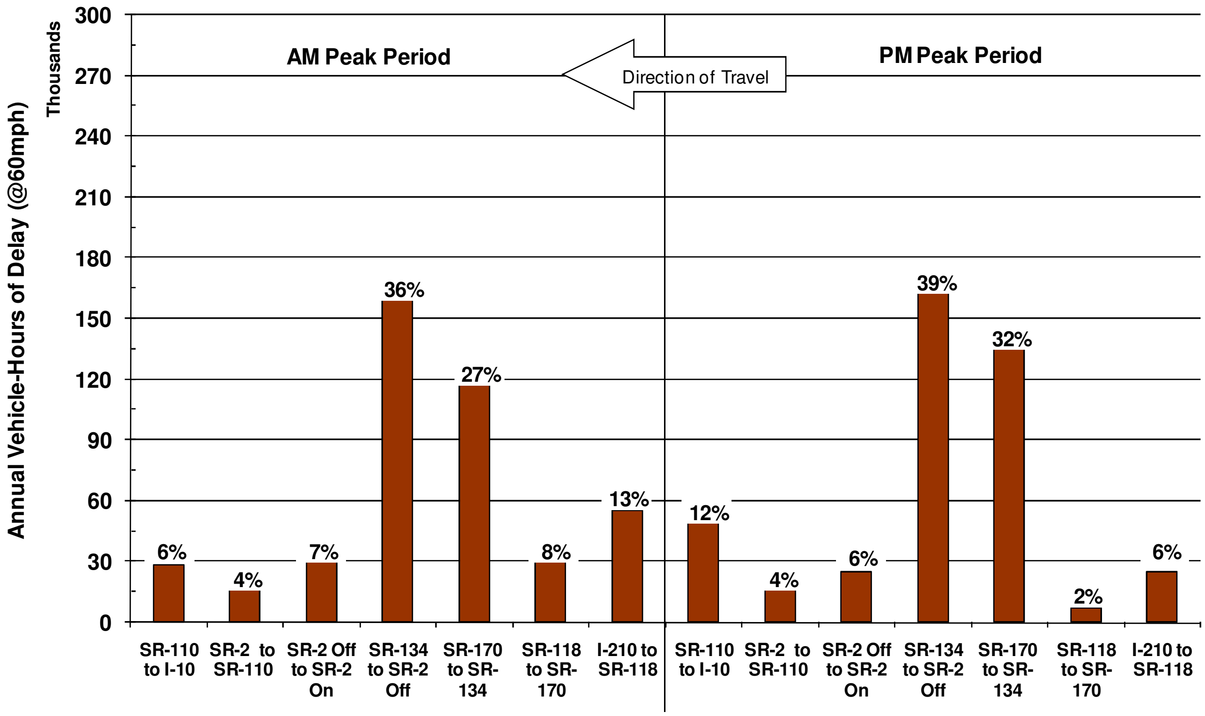
Exhibit 4C-5: Northbound I-5 Delay per Lane-Mile (2007)



Source: Caltrans detector data

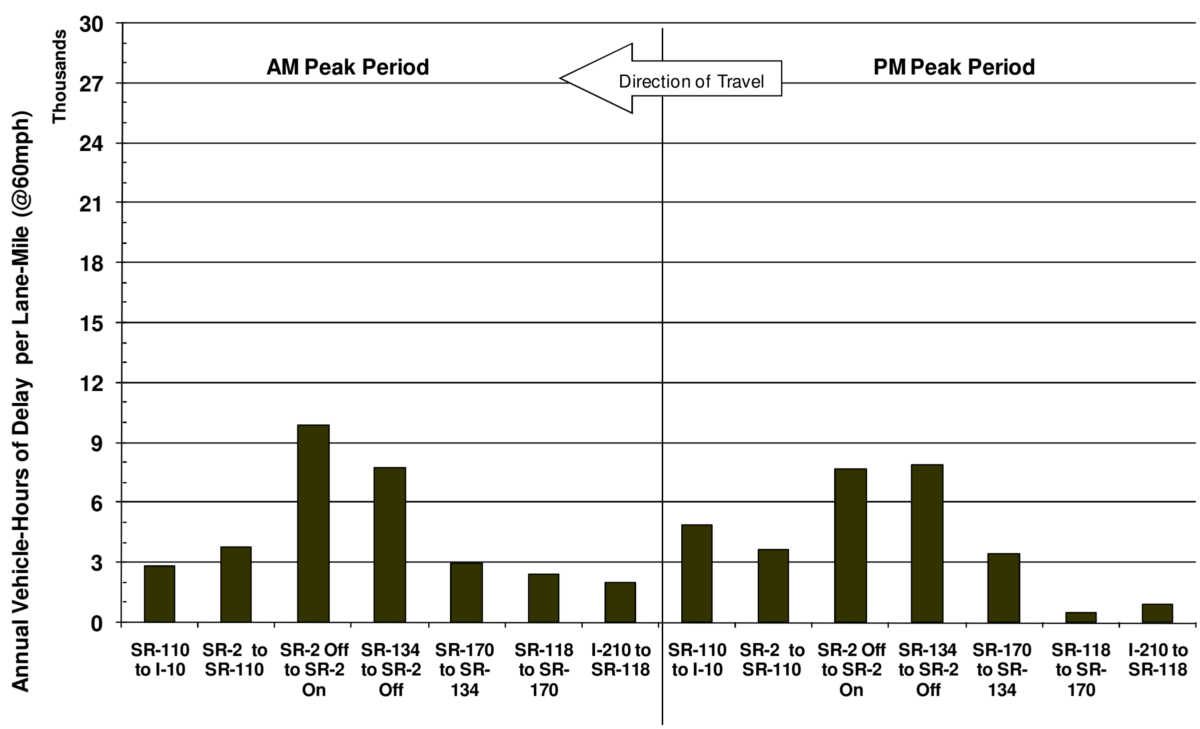
Exhibits 4C-5 and 4C-7 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. The results of these exhibits differ from Exhibits 4C-4 and 4C-6. In the northbound direction, the segment from SR-134 to Alameda experienced the highest delay per lane-mile during both peak periods. In the southbound direction, the segment from SR-2 Off to SR-2 On experienced the highest delay per lane-mile during the AM peak while the segment from SR-134 to SR-2 experienced the highest delay per lane-mile in the PM peak.

Exhibit 4C-6: Southbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: Caltrans detector data

Exhibit 4C-7: Southbound I-5 Delay per Lane-Mile (2007)



Source: Caltrans detector data

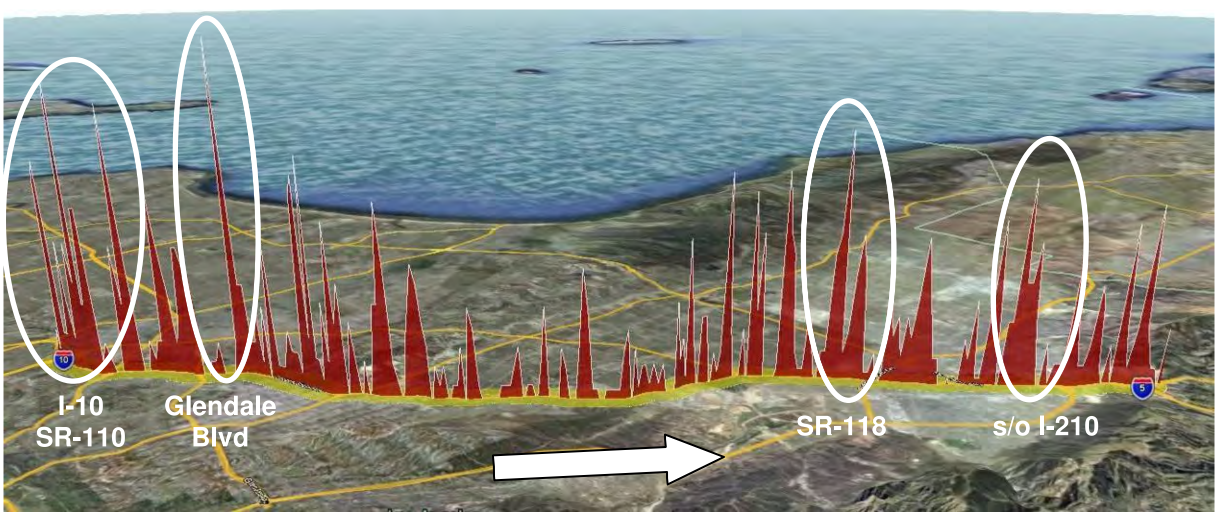
SAFETY BY BOTTLENECK AREA

As previously indicated in Section 3, the safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. The following discussion examines the pattern of collisions by bottleneck areas.

Exhibit 4C-8 shows the location of all collisions plotted along the I-5 Corridor in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within 0.1 mile segments in 2007. The highest spike corresponds to roughly 20 collisions in a single 0.1 mile location. The size of the spikes is a function of how collisions are grouped. If the data were grouped in 0.2 mile segments, the spikes would be higher.

As Exhibit 4C-8 shows, a large group of collisions occurs at the southern portion of the study corridor, between I-10 and SR-110. Other groupings occurred near Glendale Boulevard, the SR-118 interchange, and the I-210 interchange. In many cases, a spike in the number of collisions occurs in the same location as a bottleneck. For example, a spike occurred at the SR-118 interchange, which is also a bottleneck location.

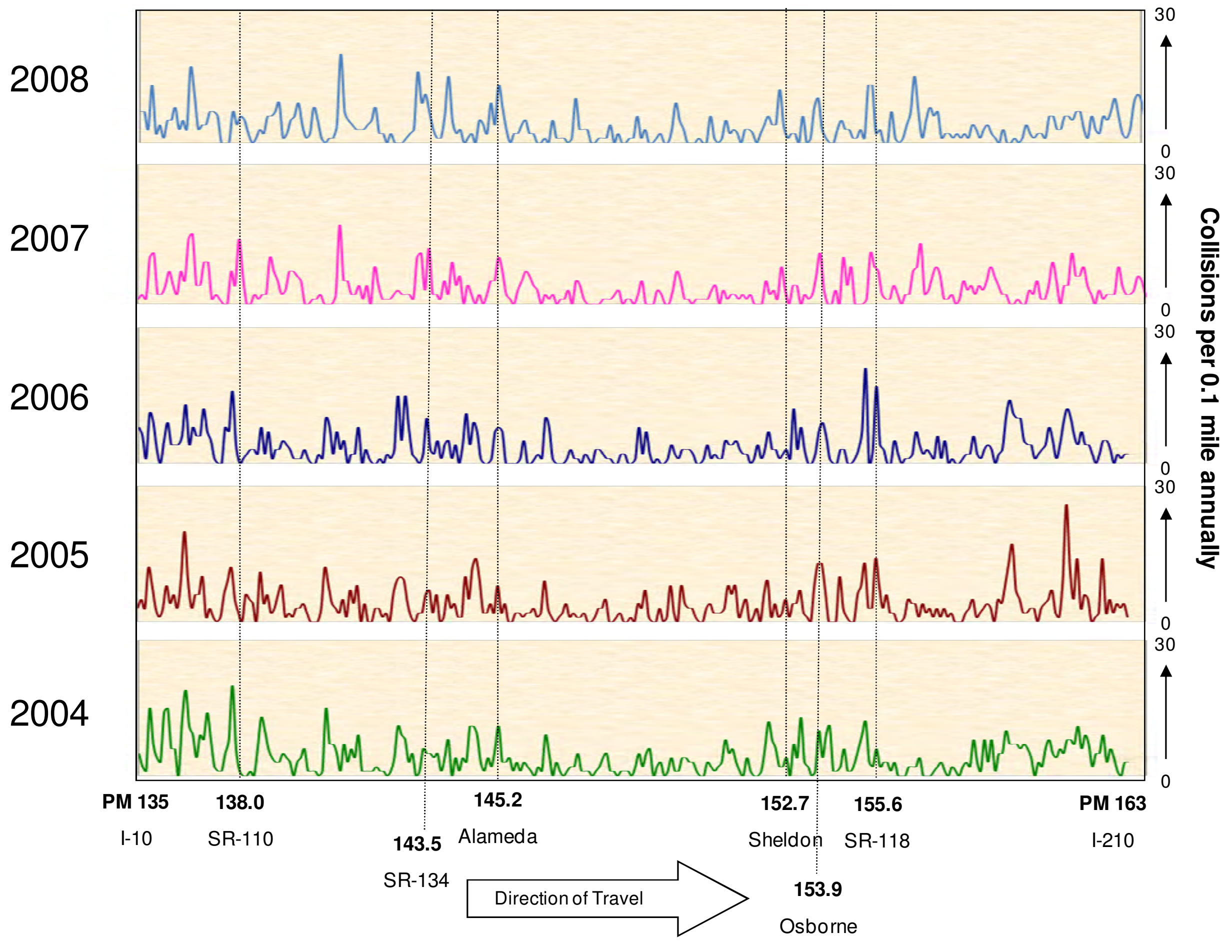
Exhibit 4C-8: Northbound I-5 Collision Locations (2007)



Source: TASAS

Exhibit 4C-9 illustrates the same data for the five-year period from 2004 to 2008. The vertical lines in the exhibit separate the corridor by bottleneck areas. As indicated in Exhibit 4C-8, a concentration of collisions exist between the I-10 and SR-110, which corresponds to the bottleneck area depicted between PM 135.0 and PM 138.0 in Exhibit 4C-9. Exhibit 4C-9 also shows that the pattern of collisions has stayed fairly consistent from one year to the next. However, the group of collisions near SR-118 (PM 155.6) has decreased from 2006.

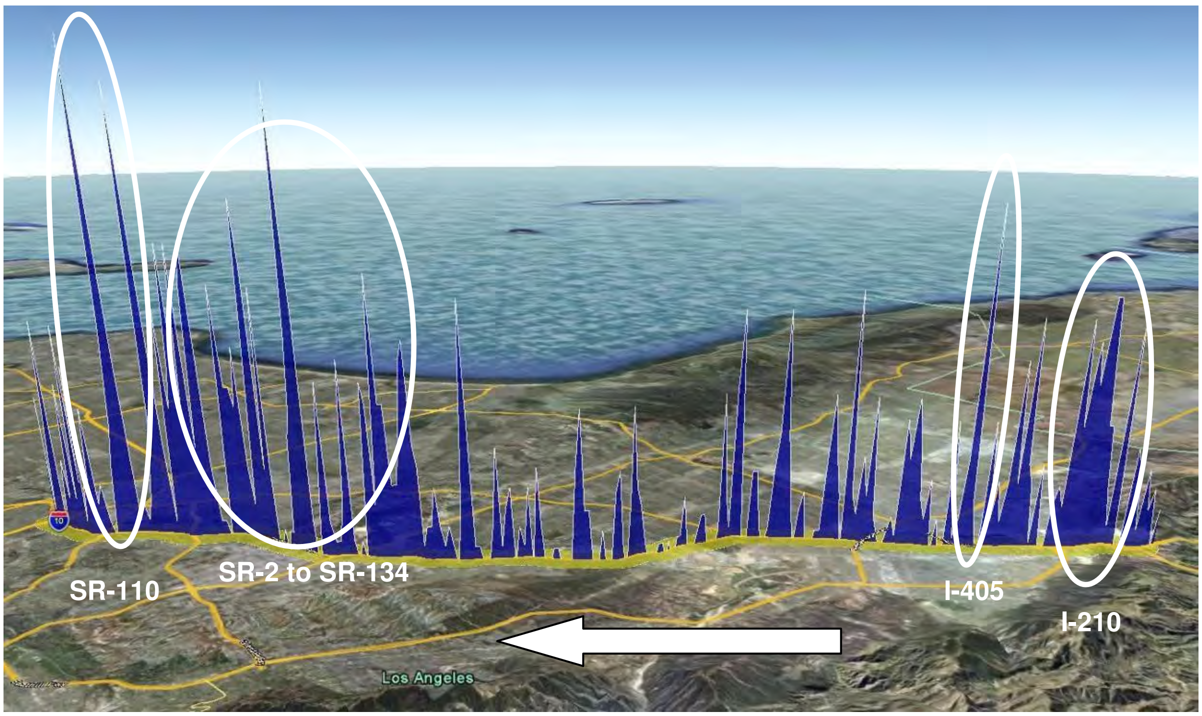
Exhibit 4C-9: Northbound I-5 Collision Locations (2004-2008)



Source: TASAS

Exhibit 4C-10 shows the same 2007 collision data for the I-5 in the southbound direction. The largest spike in this exhibit corresponds roughly to 30 collisions per 0.1 miles. The pattern in the southbound direction is similar to that in the northbound direction but with greater intensity. Again, spikes are most notable near I-210, I-405, between SR-134 and SR-2, and at the SR-110 Interchange.

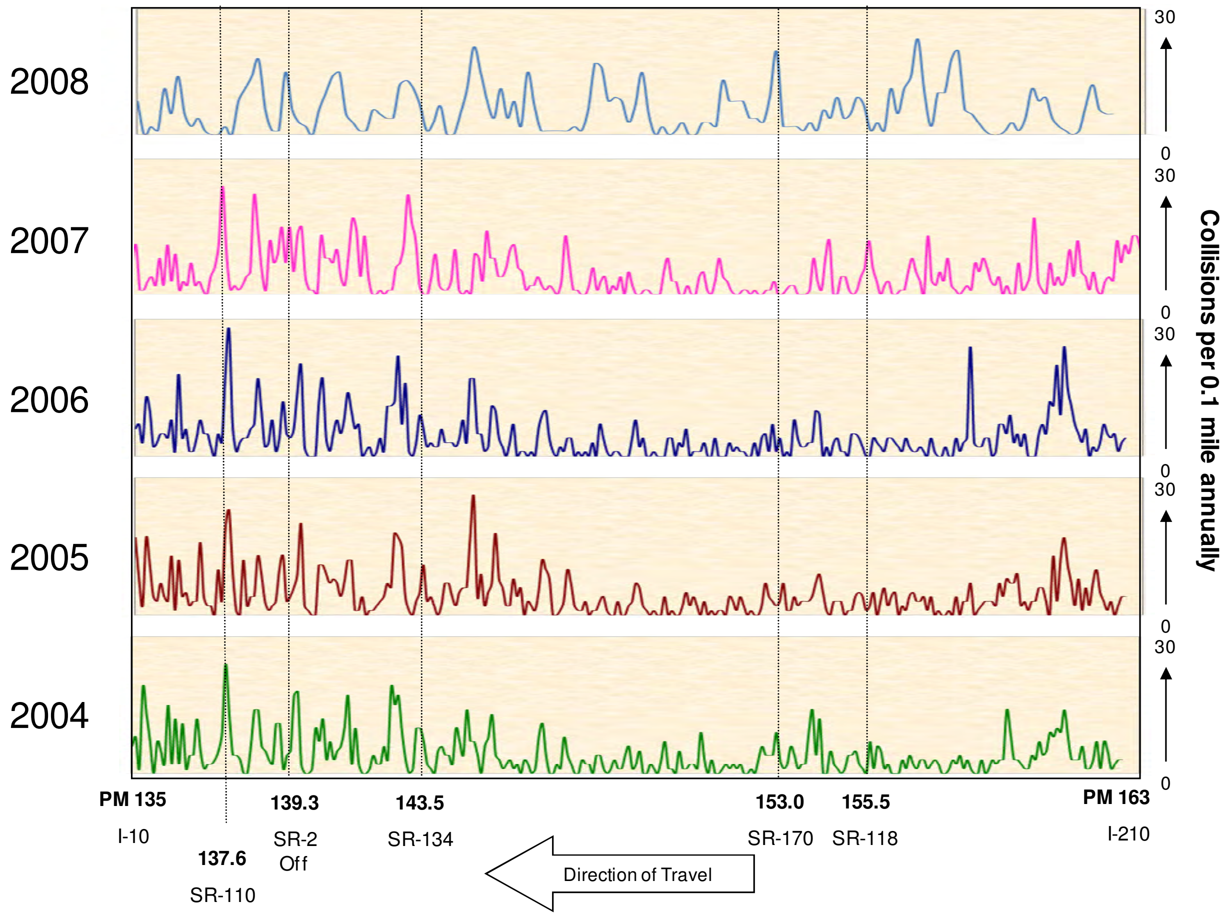
Exhibit 4C-10: Southbound I-5 Collision Locations (2007)



Source: TASAS

Exhibit 4C-11 shows the trend of annual collisions for the southbound direction from 2003 to 2007. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next, with an increase of collisions just south of SR-134 from 2006 to 2007. It also shows the high concentration that occurred in the south section of the corridor between SR-134 (PM 143.5) and I-10 (PM 135.0).

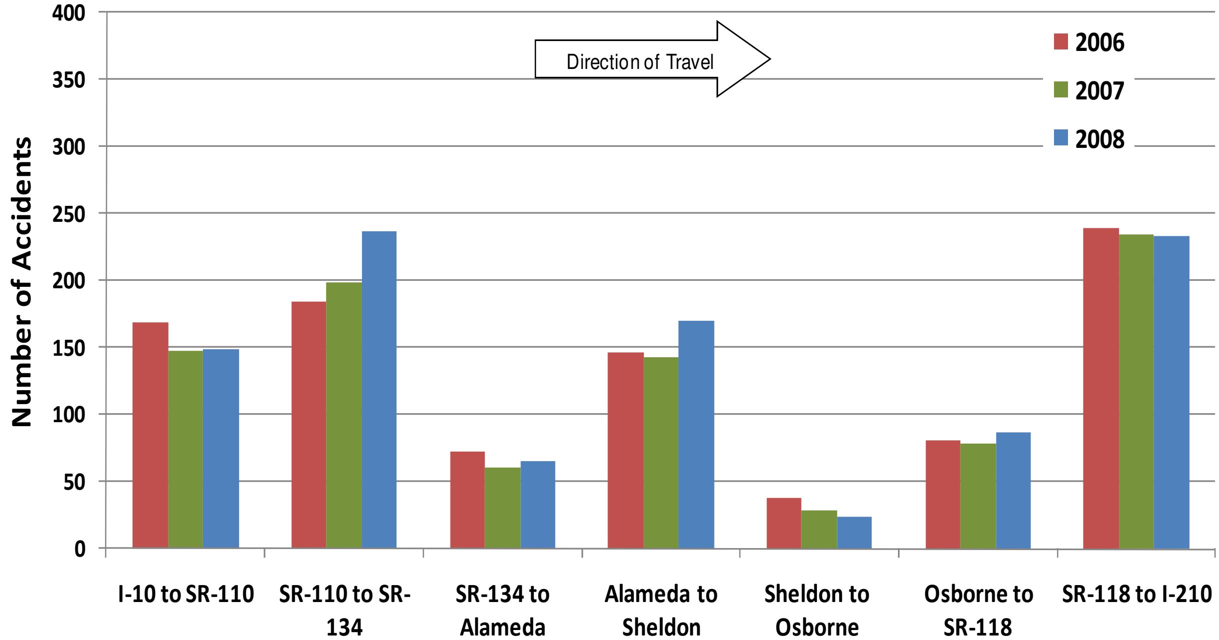
Exhibit 4C-11: Southbound I-5 Collision Locations (2004-2008)



Source: TASAS

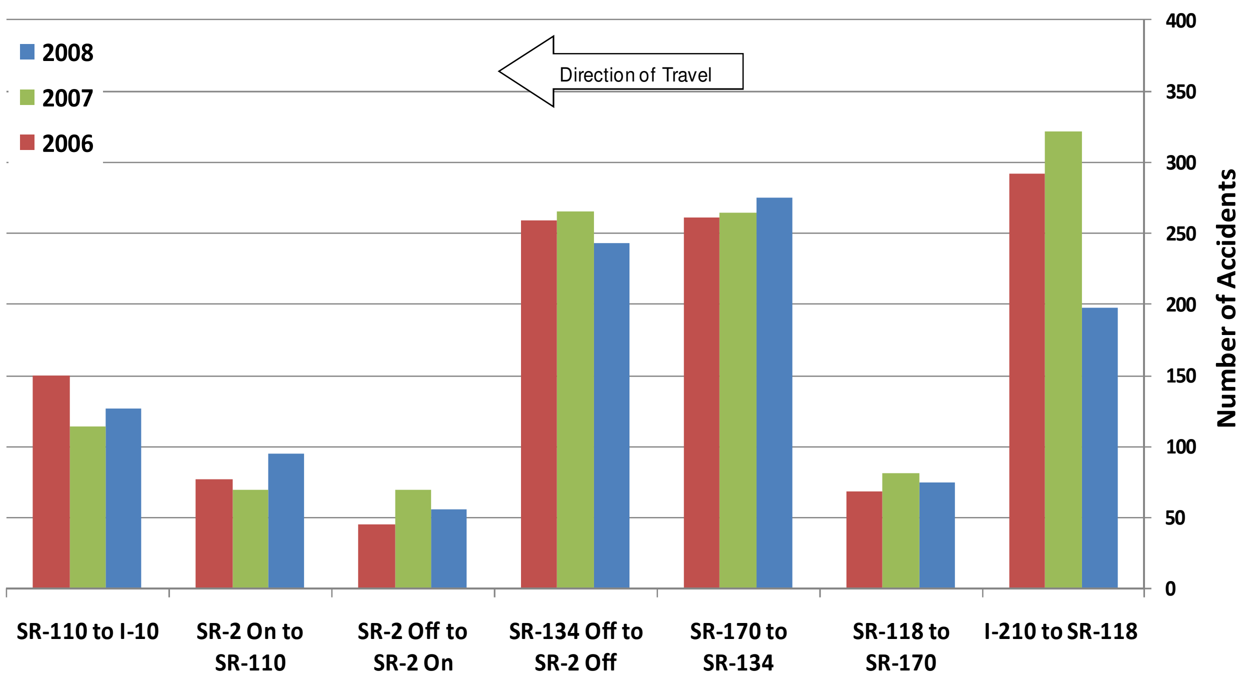
Exhibits 4C-12 and 4C-13 summarize the total number of accidents reported in TASAS by bottleneck area. The bars show the total number of annual accidents which occurred in 2006, 2007, and 2008 (the latest three years available in TASAS). In the northbound direction (Exhibit 4C-12), the segment from SR-118 to I-210 experienced the most accidents with roughly 240 each year. Similarly, in the southbound direction (Exhibit 4C-13), the same segment from I-210 to SR-118 experienced the most accidents in 2006 and 2007 with around 290 and 320, respectively. However, in 2008, the number of accidents at this location declined to less than 200.

Exhibit 4C-12: Northbound I-5 Total Accidents (2006-2008)



Source: TASAS data

Exhibit 4C-13: Southbound I-5 Total Accidents (2005-2008)



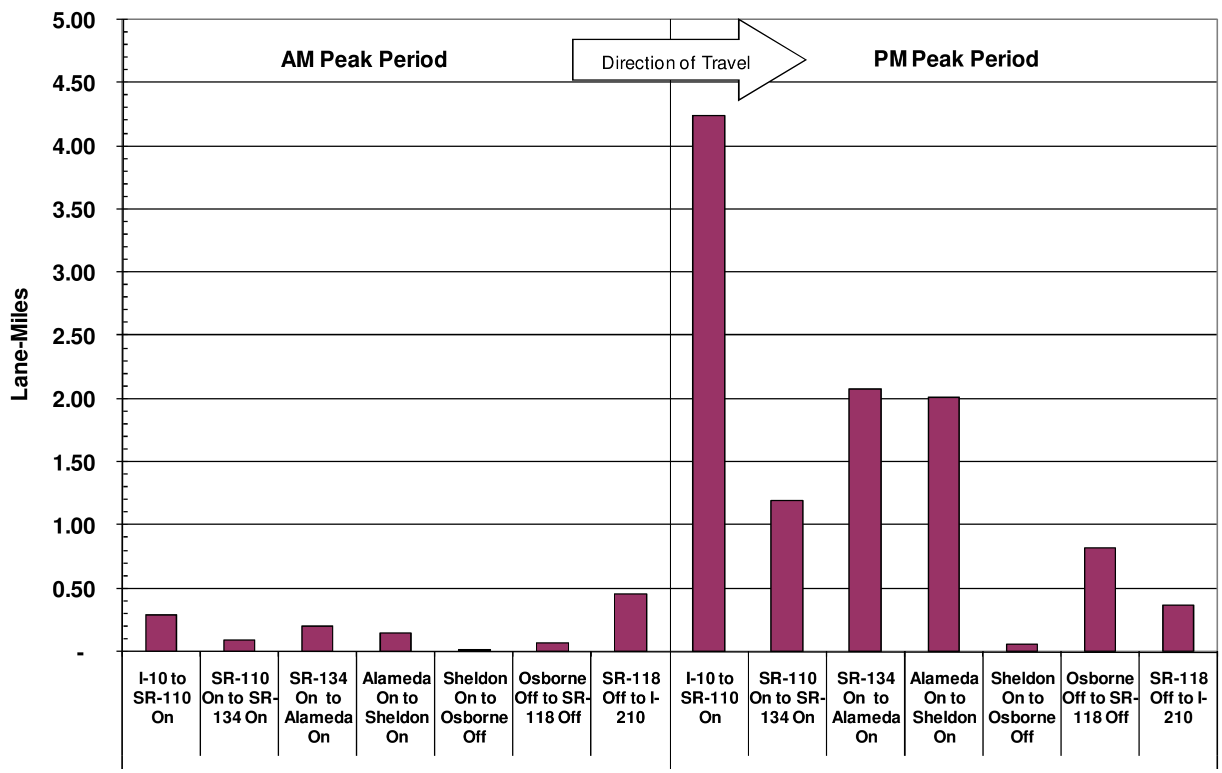
Source: TASAS data

PRODUCTIVITY BY BOTTLENECK AREA

As previously discussed in Section 3, the productivity of a corridor is defined as the percent utilization of a facility or mode under peak conditions. Productivity is measured by calculating the lost productivity of the corridor and converting it into “lost lane-miles.” These lost lane-miles represent a theoretical level of capacity that would have to be added in order to achieve maximum productivity.

Exhibits 4C-14 and 4C-15 show the productivity losses for both directions of the corridor. In the northbound direction, the segment from I-10 to SR-110 had the worst productivity of any segment on the study corridor. It experienced a productivity loss of 4.2 lane-miles during the PM peak period. During the AM peak period, the northbound direction experienced relatively high productivity with all segments of the corridor experiencing less than a half-mile of productivity loss.

Exhibit 4C-14: Northbound I-5 Equivalent Lost Lane-Miles (2007)

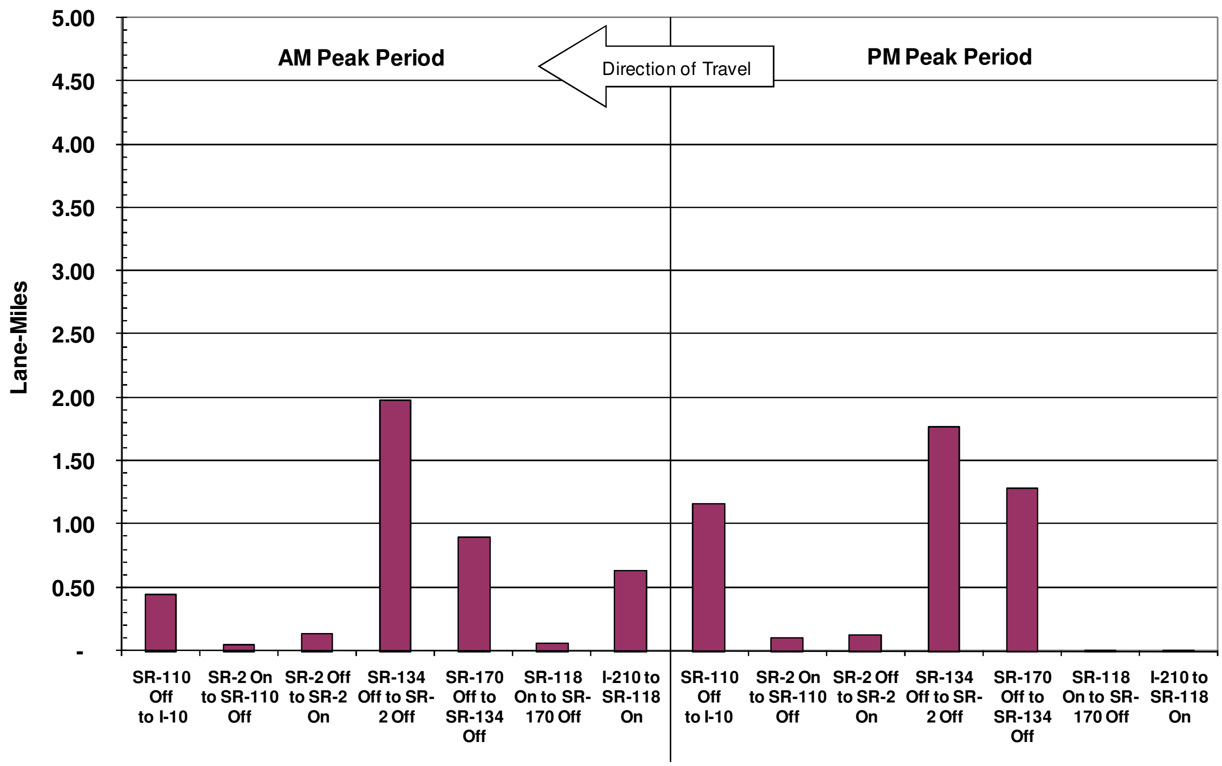


Source: Caltrans detector data

In the southbound direction, the segment from SR-134 to SR-2 Off experienced the greatest productivity loss during both peak periods with just under 2.0 lost lane-miles for each peak period.

The segments of the corridor with the highest productivity losses coincide with the segments that experience the greatest annual vehicle-hours of delay.

Exhibit 4C-15: Southbound I-5 Equivalent Lost Lane-Miles (2007)



Source: Caltrans detector data

5. SCENARIO DEVELOPMENT AND ANALYSIS

The previous sections presented the diagnostic part of the CSMP effort. They describe the corridor, examine its performance trends, and pinpoint its bottlenecks and related causes. This section describes the improvement evaluation component of the CSMP effort. It describes the logic behind developing the scenarios to be evaluated and presents the mobility results estimated by using the Vissim micro-simulation model. It also summarizes the overall benefit cost analysis results conducted to compare costs to benefits. The following steps are discussed in more detail below:

- Developing traffic models for 2007 base year and 2020 long-term demand
- Combining projects in a logical manner for modeling and testing
- Evaluating model outputs and summarizing results
- Conducting a benefit-cost assessment of scenarios.

Traffic Model Development

The study team developed a traffic model using the VISSIM micro-simulation software. It is important to note that micro-simulation models are complex to develop and calibrate for a large urban corridor. However, it is one of the only tools capable of providing a reasonable approximation of bottleneck formation and queue development. Therefore, such tools help quantify the impacts of operational strategies, which traditional travel demand models cannot.

The model was calibrated against 2007 conditions. This was a resource-intensive effort, requiring several submittal and review cycles until the model reasonably matched bottleneck locations and relative severity. Once calibration was approved, a 2020 model was also developed based on SCAG's travel demand model projections. Caltrans selected 2020 as the horizon year to test operational improvements and other system management strategies.

These two models were used to evaluate different scenarios (combinations of projects) to quantify the associated congestion relief benefits and to compare total project costs against their benefits.

Exhibit 5-1 depicts the network included in the model. There are no parallel arterials in the model with the exception of arterials at interchanges. All freeway interchanges were included as well as on-ramps and off-ramps.

Exhibit 5-1: I-5 North Micro-Simulation Model Network

Scenario Development Framework

The study team developed a framework for combining projects into scenarios. It would be desirable to evaluate every possible combination of projects. However, this would have entailed thousands of model runs. Instead, the team combined projects based on a number of factors, including:

- Projects that were fully programmed and funded were combined separately from projects that were not fully programmed.
- Operational projects were generally combined separately from expansion projects in order to distinguish between their benefits.

- Short-term projects to be delivered by 2011 were used to develop scenarios to be tested with the 2007 model.
- Long-term projects to be delivered by 2020 were used to develop scenarios to be tested with the 2020 model.

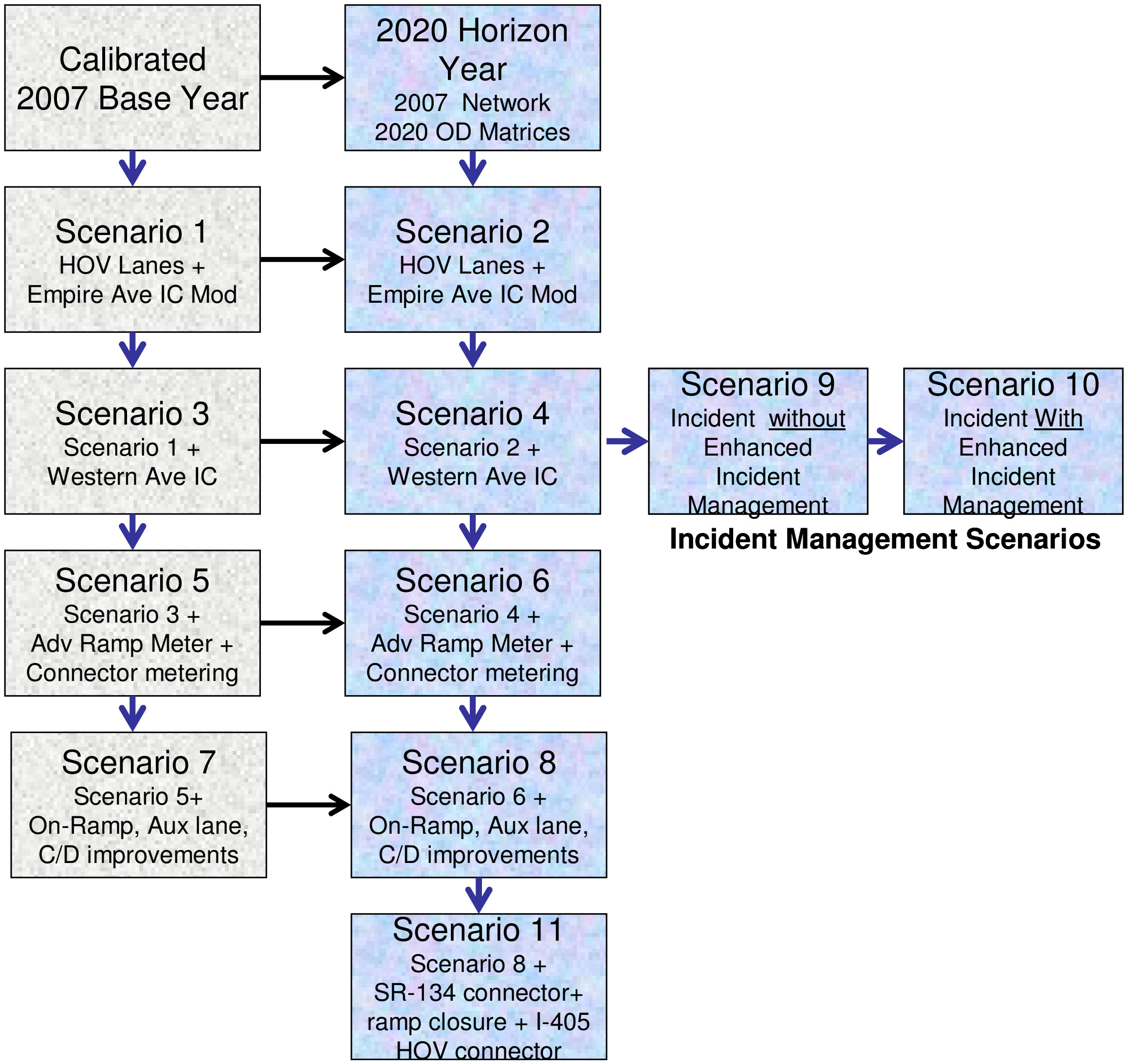
The study team assumed that projects delivered before 2011 could reasonably be evaluated by using the 2007 base year model. The 2020 forecast year for the I-5 North corridor was consistent with the SCAG regional travel demand model origin-destination matrices. When SCAG updates its travel demand model and Regional Transportation Plan (RTP), Caltrans may wish to update the micro-simulation model with revised demand projections.

Project lists used to develop scenarios were provided by SCAG and Caltrans from the Regional Transportation Improvement Program (RTIP), the RTP, the State Highway Operation and Protection Program (SHOPP), and other sources (e.g., special studies). The study team eliminated projects that do not directly affect mobility. For instance, sound wall, landscaping, or minor arterial improvement projects were eliminated since micro-simulation models cannot evaluate them.

Scenario testing for the I-5 North Corridor CSMP differed from traditional "alternatives evaluations" done for Major Investment Studies (MIS) or Environmental Impact Reports (EIRs). An MIS or EIR focuses on identifying alternative solutions to address current or projected corridor problems, so each alternative is evaluated separately and results among competing alternatives are compared resulting in a locally preferred alternative. In contrast, for the I-5 North Corridor CSMP, scenarios build on each other. Each scenario contains the projects from the previous scenario plus additional projects as long as the incremental scenario results showed an acceptable level of performance improvement. This incremental scenario evaluation approach is important to understand since CSMPs are new and often compared with alternatives studies.

Exhibit 5-2 summarizes the approach used and scenarios tested. It also provides a general description of the projects included in the 2007 and 2020 micro-simulation runs. As can be seen in the exhibit, most projects were tested in both the short-term and long-term and built upon prior scenarios. Enhanced incident management was tested in Scenarios 9 and 10 by comparing congestion with and without enhanced incident management. These scenarios assume that the prior scenario projects were built in the horizon year model and are expected for the longer term and were not tested using the short-term model. Appendix A provides the detailed project list included in each scenario.

Exhibit 5-2: Micro-Simulation Modeling Approach



Scenario Evaluation Results

Exhibits 5-3 and 5-4 show the delay results for all the 2007 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits 5-5 and 5-6 show the delay results for all the 2020 scenarios evaluated for the AM and PM peak periods, respectively. The percentages shown in the exhibits indicate the difference in delay between the current scenario and the previous scenario (e.g., Percent Change = (Current Scenario/Previous Scenario)/Previous Scenario). Impacts of strategies differ based on a number of factors such as traffic flow conditions, ramp storage, bottleneck locations, and levels of congestion.

For each scenario, the modeling team produced results by facility type (i.e., mainline, HOV, arterials, and ramps) and vehicle type (SOV, HOV, and trucks) as well as speed contour diagrams (discussed in more detail in the full technical CSMP). The study team scrutinized the results to ensure that they were consistent with general traffic engineering principles. The following sections summarize findings for each scenario tested and reviewed by the study team.

A traffic report with all the model output details is available under separate cover.

Exhibit 5-3: AM Peak Micro-Simulation Delay Results by Scenario (2007)

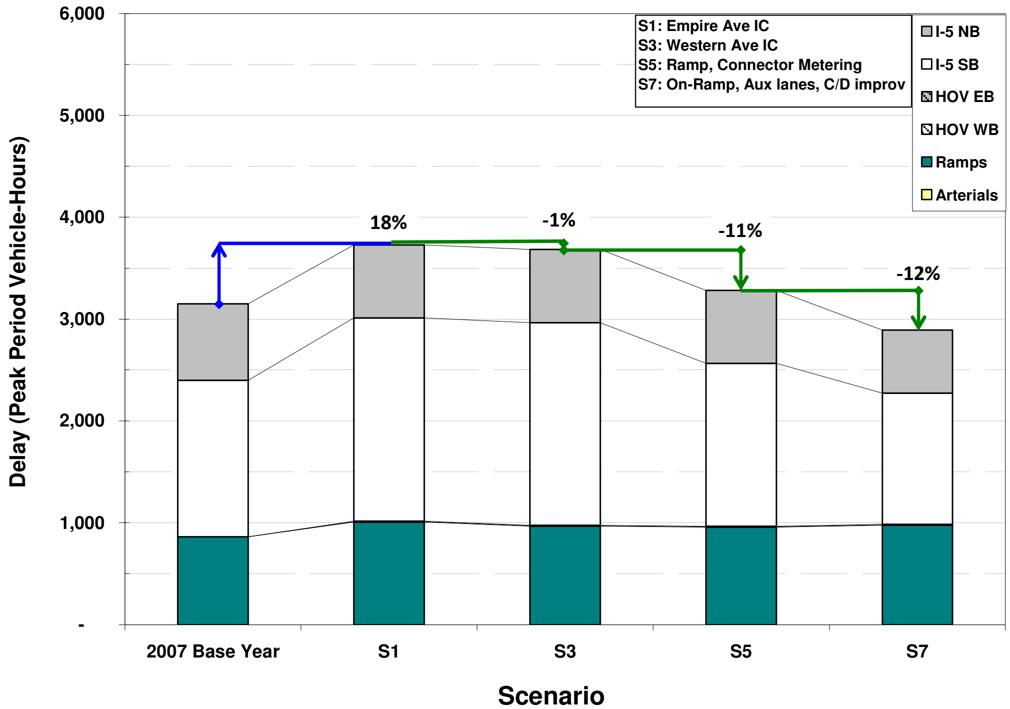


Exhibit 5-4: PM Peak Micro-Simulation Delay Results by Scenario (2007)

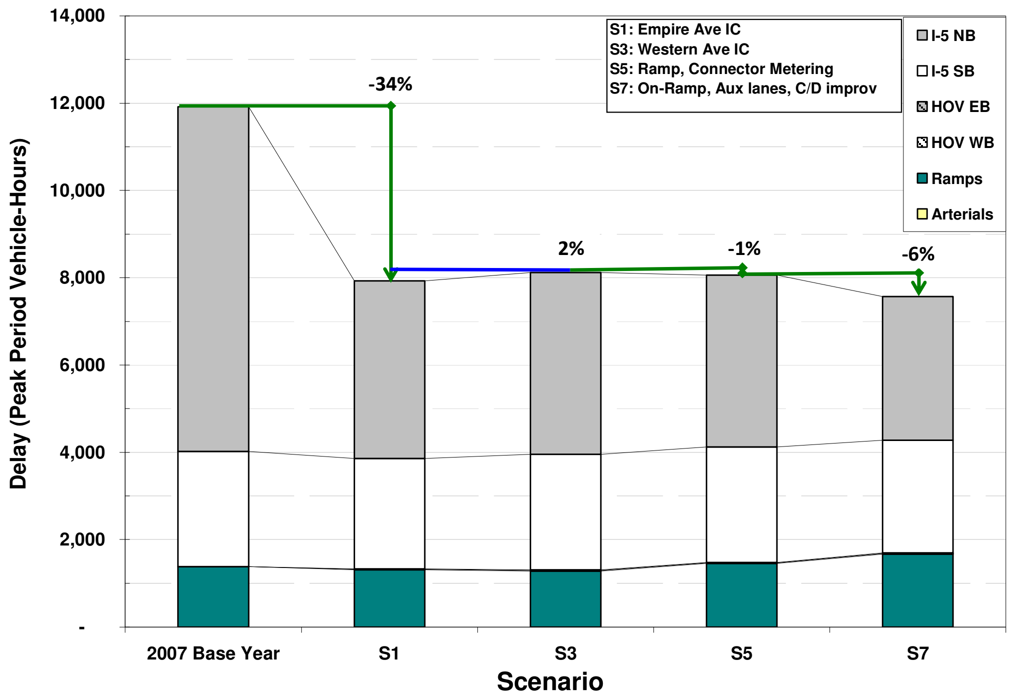


Exhibit 5-5: AM Peak Micro-Simulation Delay Results by Scenario (2020)

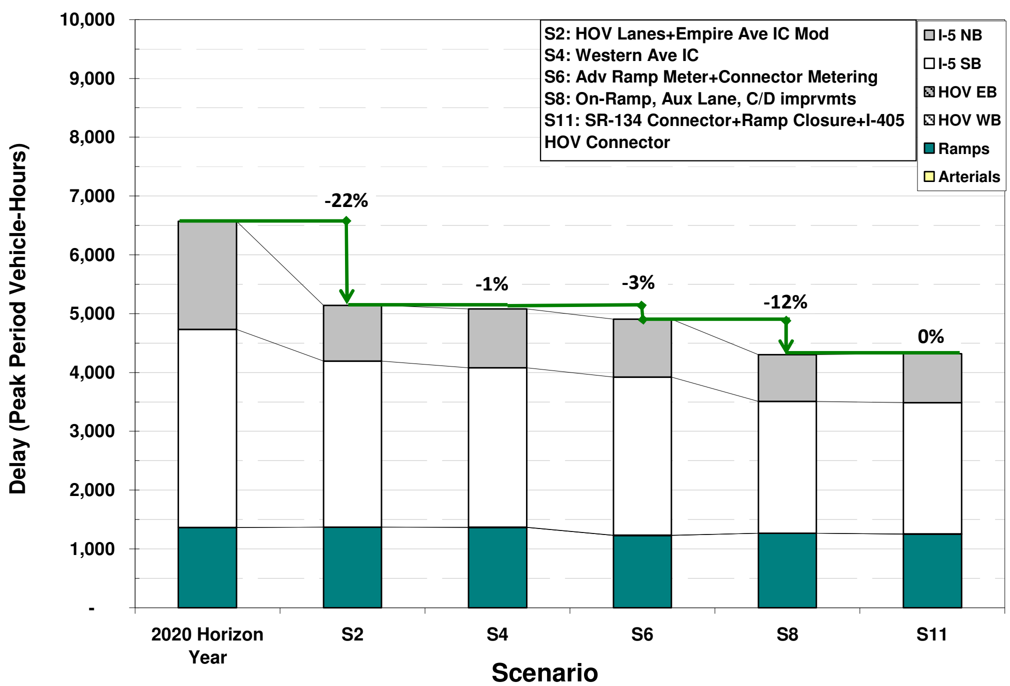
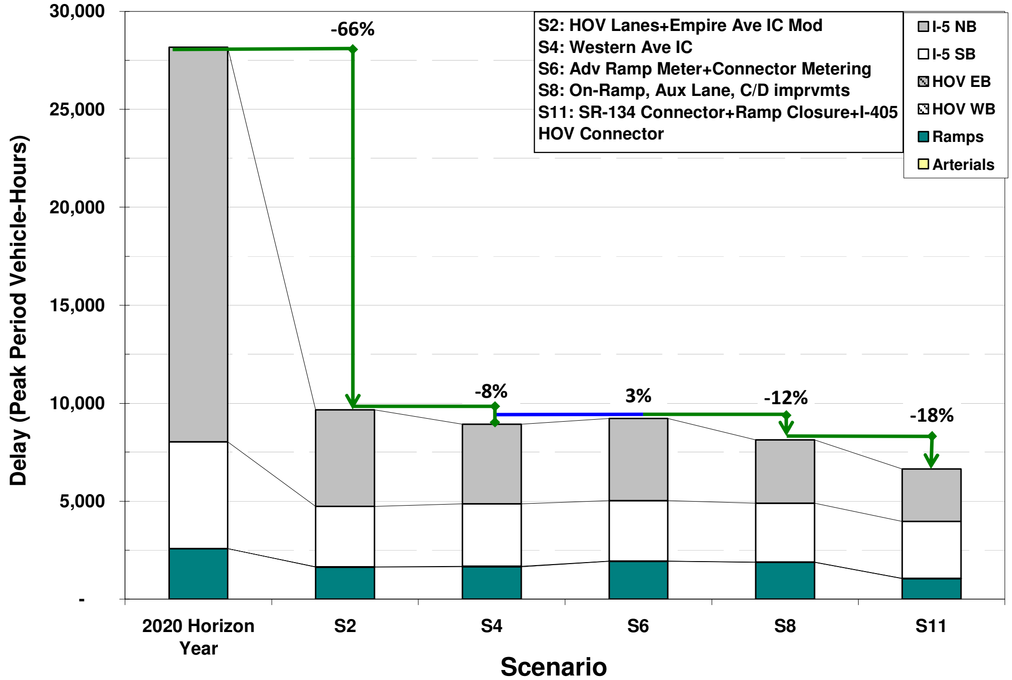


Exhibit 5-6: PM Peak Micro-Simulation Delay Results by Scenario (2020)



Exhibits 5-7 through 5-10 summarize the delay results of the 2007 base year model by bottleneck area for the northbound and southbound directions and for each peak period. Exhibits 5-11 through 5-14 report the delay results of the 2020 horizon year model.

Exhibit 5-7: Northbound AM Delay by Scenario and Bottleneck Area (2007)

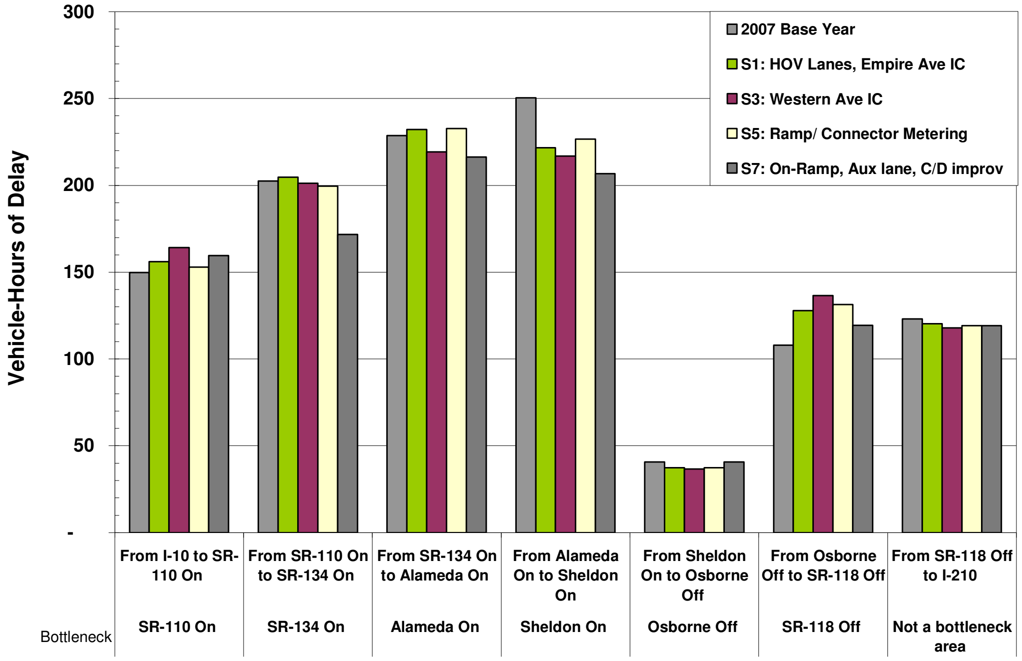


Exhibit 5-8: Northbound PM Delay by Scenario and Bottleneck Area (2007)

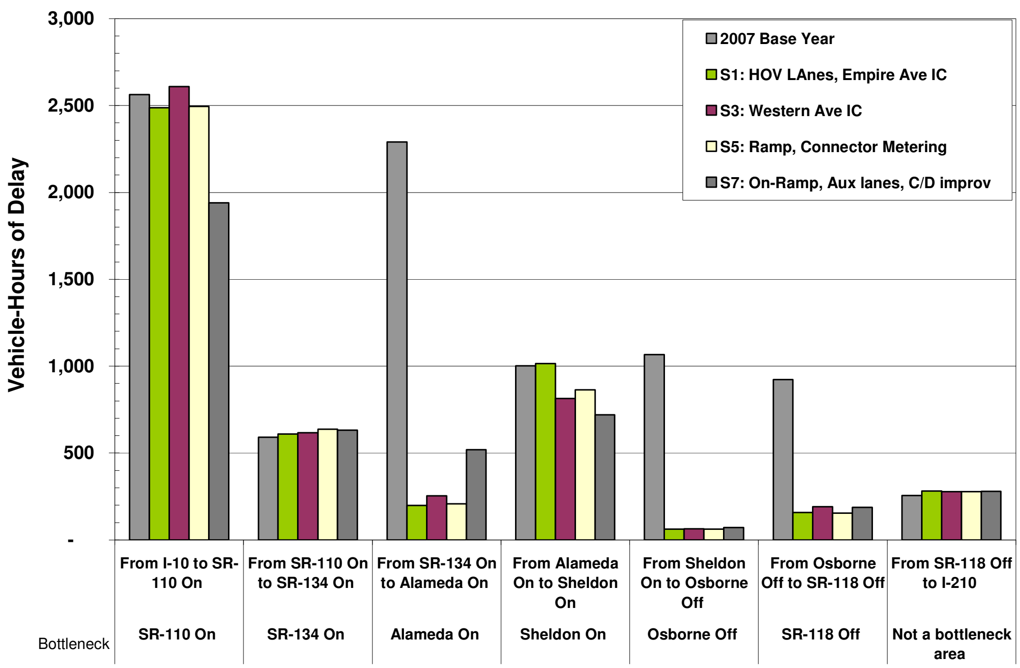


Exhibit 5-9: Southbound AM Delay by Scenario and Bottleneck Area (2007)

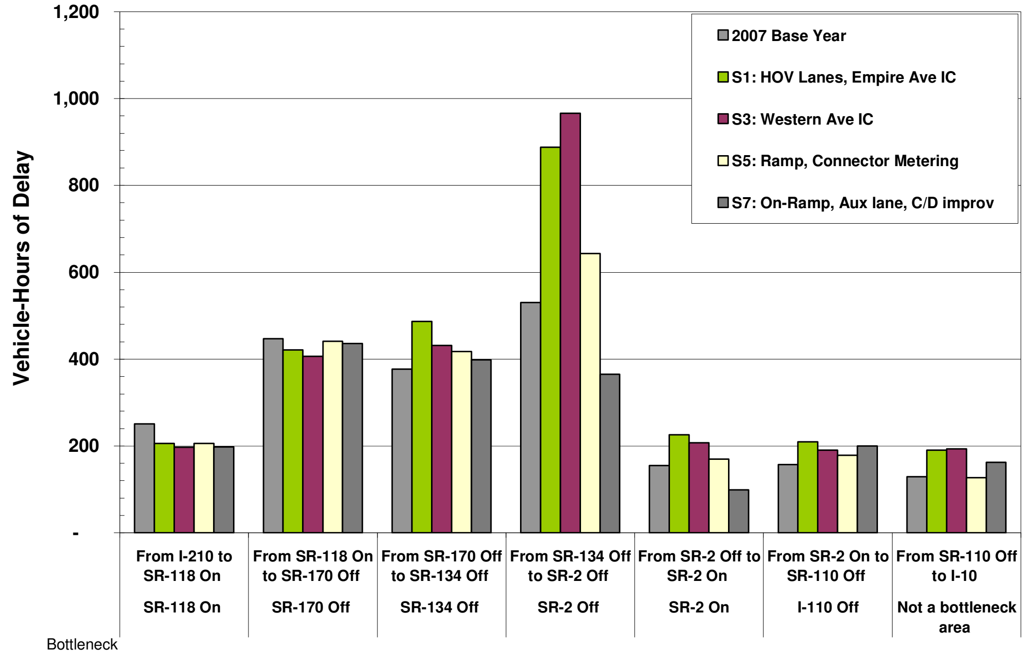


Exhibit 5-10: Southbound PM Delay by Scenario and Bottleneck Area (2007)

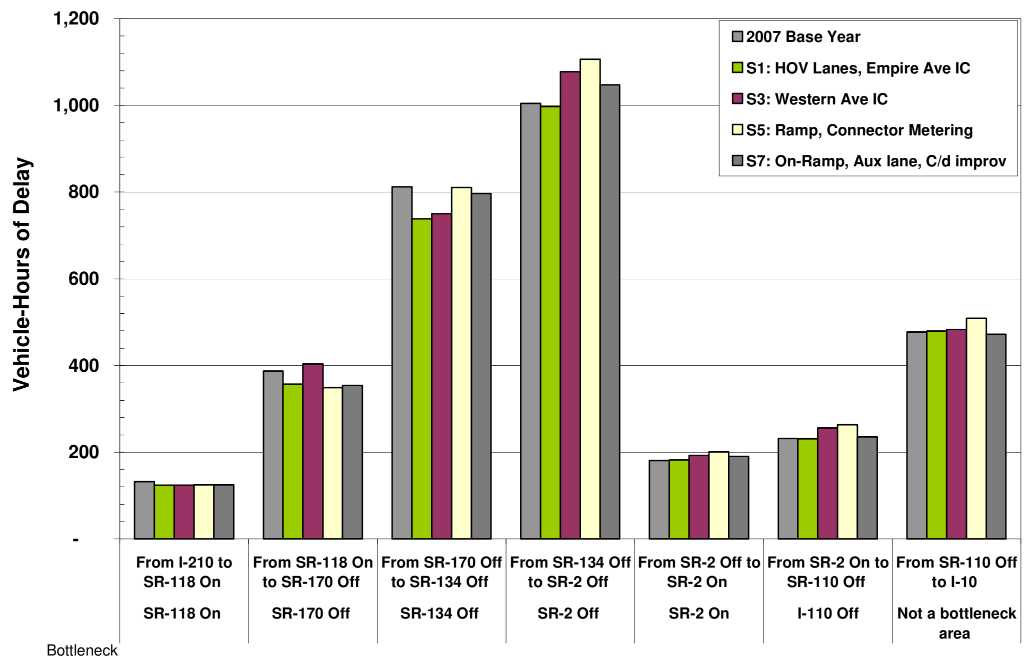


Exhibit 5-11: Northbound AM Delay by Scenario and Bottleneck Area (2020)

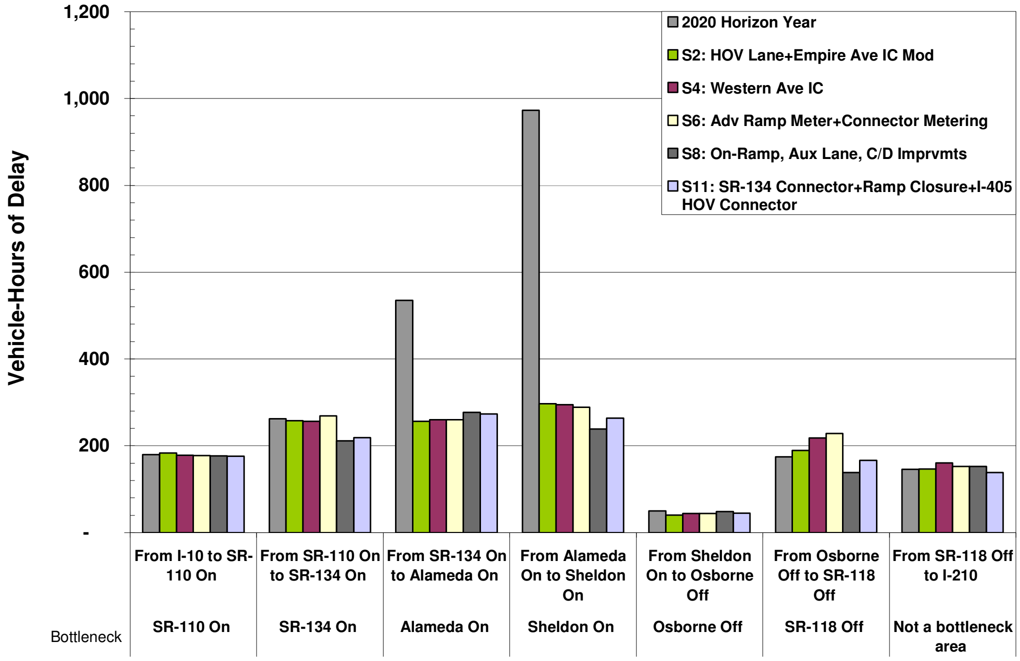


Exhibit 5-12: Northbound PM Delay by Scenario and Bottleneck Area (2020)

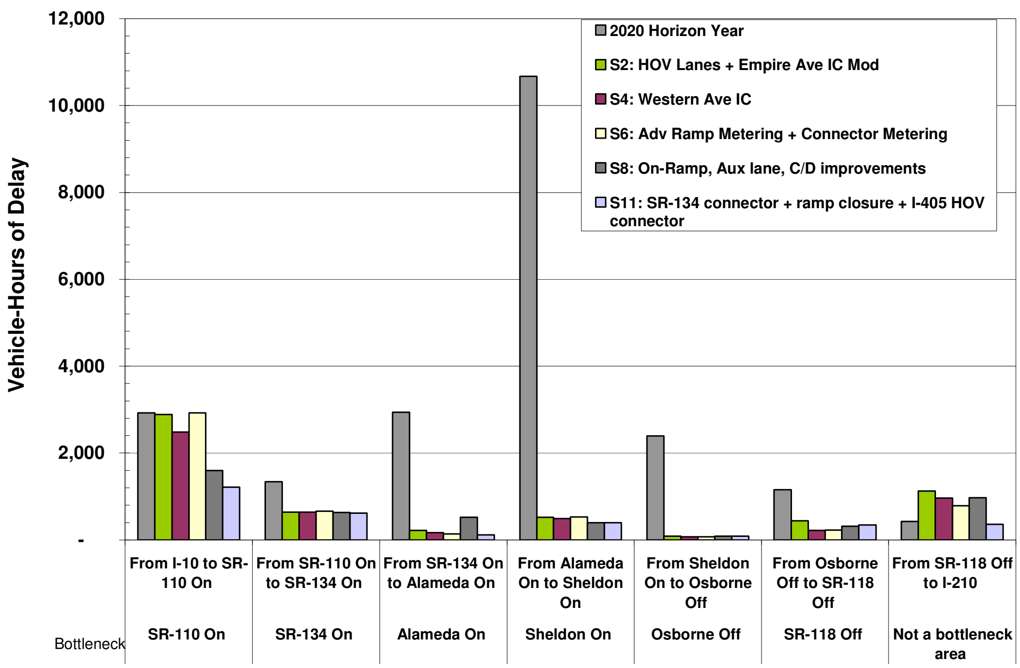


Exhibit 5-13: Southbound AM Delay by Scenario and Bottleneck Area (2020)

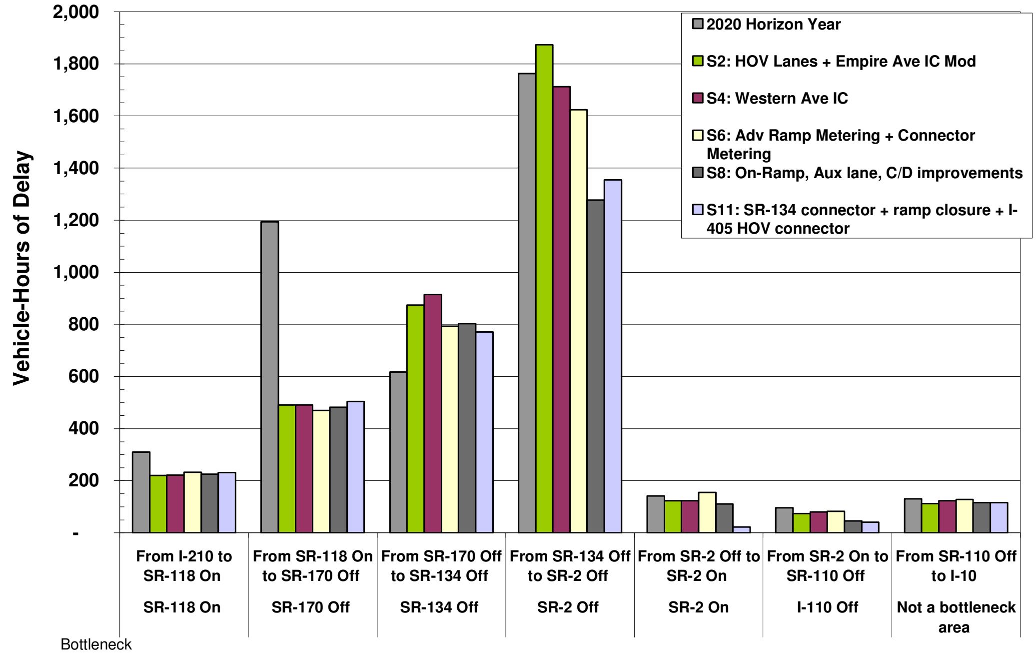
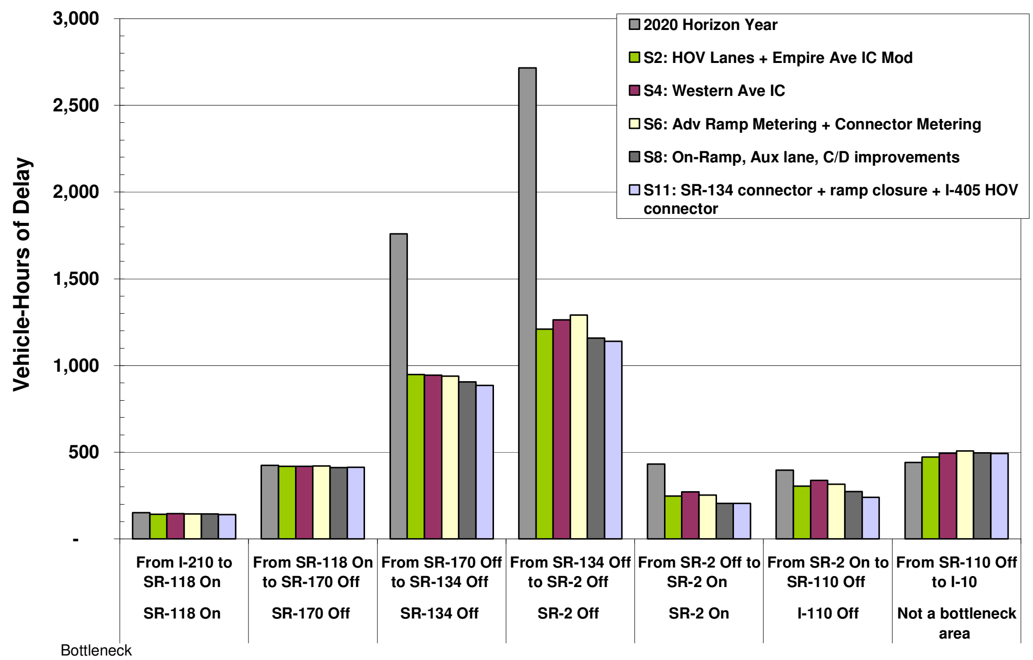


Exhibit 5-14: Southbound PM Delay by Scenario and Bottleneck Area (2020)



The following describes the findings for each scenario tested and reviewed by the study team:

2007 Base Year and 2020 Do Minimum Horizon Year

Absent any physical improvements, the modeling team estimates that by 2020, total delay (mainline, HOV, and ramps) will more than double compared to 2007 (from a total of around 15,000 hours daily to more than 35,000 hours). As described below, the short term programmed projects lead to significant decreases and improved mobility on the corridor.

Scenarios 1 and 2 (HOV Lanes + Empire Ave Interchange Modification)

The first two scenarios include both completed (from 2008 to 2010) and fully funded programmed projects, including CMIA funded projects slated for completion by 2011. These projects include:

- Add one HOV lane in each direction from SR-118 to SR-14 (completed in 2008)
- Add one HOV lane in each direction from SR-134 to SR-170 (CMIA)
- Modify the Empire Avenue interchange; construct auxiliary lanes in both directions between Burbank Boulevard and Empire Avenue
- Add one HOV lane in each direction from SR-170 to SR-118, Construct I-5/SR-170 HOV to HOV connector; reconstruct I-5/SR-170 mixed flow connector.

The 2007 model estimates that these projects would reduce overall delay on the corridor by approximately 23 percent or about 3,500 vehicle-hours for both AM and PM peak period combined. It estimates that the PM peak period delay would decrease by approximately 34 percent or about 4,000 vehicle-hours. However, it would increase in the AM peak period by 18 percent or about 600 vehicle-hours, mostly in the southbound direction at the downstream segments where the HOV lane terminates and merges with the mainline traffic stream.

The 2020 model estimates that the projects would reduce total delay on the corridor by over 57 percent, almost 20,000 vehicle-hours for both AM and PM peak period combined. While both the AM and PM peak periods are estimated to reduce delay, the more significant reduction in delay occurs during the PM peak period when it drops from 28,000 vehicle-hours to 9,700 vehicle-hours with implementation of the HOV and interchange modification projects. The largest reduction in delay is estimated to occur in the northbound direction from Alameda to Sheldon.

Scenarios 3 and 4 (Western Avenue Interchange)

Scenarios 3 and 4 build on Scenarios 1 and 2 by adding a fully funded and programmed interchange improvement project at the Western Avenue interchange by realigning on- and off-ramps and providing for more capacity at the northbound Western Avenue off-ramp to Flower Street.

The 2007 model estimates that with the Western Avenue interchange improvements, not much change in the delay are expected either in the AM or PM peak periods on the freeway corridor, although they are expected to improve local circulation and access while removing the currently inefficient collector/distributor interchange configuration.

Scenarios 5 and 6 (Advanced Ramp Metering + Connector Metering)

Scenarios 5 and 6 build on Scenarios 3 and 4 by adding advanced ramp metering system such as dynamic or adaptive ramp metering system with connector metering with queue control (to ensure queuing does not exceed the capacity of the connector) at the following locations:

- SR-118 connector ramp to I-5
- Southbound SR-2 connector ramp to I-5.

The 2007 model indicates that the projects would reduce delay in the AM peak by over 10 percent or 400 vehicle-hours and there would be negligible change in the PM peak. The 2020 model shows that the projects would reduce delays in the AM peak by three percent or 175 vehicle-hours, but could increase delays in the PM peak also by three percent, almost 300 vehicle-hours. Overall, the two models estimate that advanced ramp and connector metering would reduce congestion along the corridor by approximately 350 vehicle-hours of delay.

There are various types of advanced ramp metering systems deployed around the world, including the System-wide Adaptive Ramp Metering System (SWARM) tested on Los Angeles I-210 freeway corridor. For modeling on the I-5 South Corridor, the Asservissement Lineaire d'Entrée Autoroutiere (ALINEA) system was tested as proxy for any advanced ramp metering system, since its algorithm for the model was readily available (and the algorithm for SWARM was not). However, the study team is not necessarily recommending ALINEA be deployed on I-5, but rather some type of advanced ramp metering system that would produce similar or better results.

Scenarios 7 and 8 (Operational Improvements)

Scenarios 7 and 8 build on Scenarios 5 and 6 by adding the following operational improvement projects proposed by the study team and Caltrans Traffic Operations staff:

- Extend the northbound I-10 on-ramp to improve merging
- Modify the Pasadena Avenue on-ramp to merge into the new collector-distributor (from Broadway) and move on-ramp merge further downstream
- Modify Riverside Drive on-ramp to northbound SR-110 on-ramp; reduce the SR-110 merge to one lane before merge with northbound I-5
- Restripe the northbound SR-134 on-ramp merge to solid white striping 1000-feet downstream of merge point; reduce on-ramp merge to one lane further upstream
- Modify the northbound Alameda interchange to eliminate the collector-distributor
- Modify the northbound Sheldon interchange to eliminate the collector-distributor
- Extend the fourth southbound lane through the SR-2 interchange.

The 2007 model shows that the combination of these projects would produce over 10 percent reduction in delay in the AM peak period and over five percent reduction in delay in the PM peak period, a total of 880 vehicle-hours. The 2020 model also shows a significant reduction of over 10 percent in delay in both the AM and PM peak periods, over 1,500 vehicle-hours reduction.

Scenarios 9 and 10 (Enhanced Incident Management)

Two incident scenarios that build on top of Scenario 4 were tested with only the 2020 model to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. The proposed enhanced incident management strategies would entail upgrading or enhancing the current Caltrans incident management system that includes deployment of intelligent transportation system (ITS) field devices, central control/communications software, communications medium (i.e. fiber optic lines), advanced traveler information system, and/or freeway service patrol (FSP) program to reduce incident detection, verification, response, and clearance times.

In the first scenario (Scenario 9), one collision incident with one outside lane closure was simulated in the southbound direction in the AM peak period model and also one in the northbound direction in the PM peak period model. The incident simulation location and duration was selected based on review of the 2010 actual incident data at one of the high frequency locations. The following are the scenario details:

- Southbound AM peak period starting at 7:00 AM, close outermost mainline lane for 35 minutes at absolute post mile 140.7 (at Los Feliz)
- Northbound PM peak period starting at 5:00 PM, close outermost mainline lane for 40 minutes at absolute post mile 138.8 (south of SR-2).

In the second scenario (Scenario 10), the same collision incidents were simulated with a reduction in duration by 10 minutes for both incidents. It is estimated, based on actual incident management data analysis results provided by Caltrans, that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes.

These scenarios represent a typical moderate incident at one location during the peak period direction. Data suggest that incidents vary significantly in terms of impact and duration. Some incidents last hundreds of minutes, some close multiple lanes, and some occur at multiple locations simultaneously. There are also numerous minor incidents without lane closures that last only a few minutes that also result in congestion. There are also many incidents that occur during off-peak periods.

Exhibits 5-15 and 5-16 show the delay results by facility type and peak period for the enhanced incident management scenarios that were evaluated using the 2020 base year model. Without enhanced incident management, the first scenario produced nearly 60 percent increase in delay in the AM peak and over 10 percent increase in delay in the PM peak over Scenario 4, an increase of over 4,000 vehicle-hours of delay. With enhanced incident management strategies by reducing duration by just 10 minutes, a decrease in delay of nearly 1,500 vehicle-hours could result with the improved detection, verification, response, and clearance time of one moderate level incident of both of the peak periods. These results reflect benefits realized during the peak direction period. Additional benefits would be realized during off-peak hours and in the off-peak direction.

Exhibit 5-15: AM Delay Results for Enhanced Incident Management (2020)

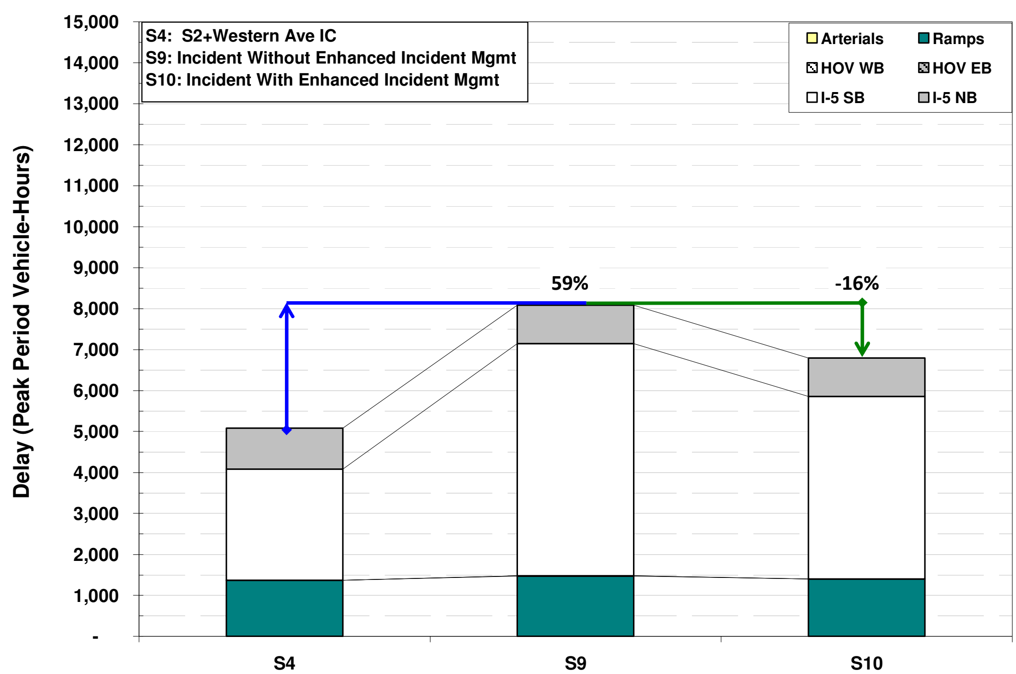
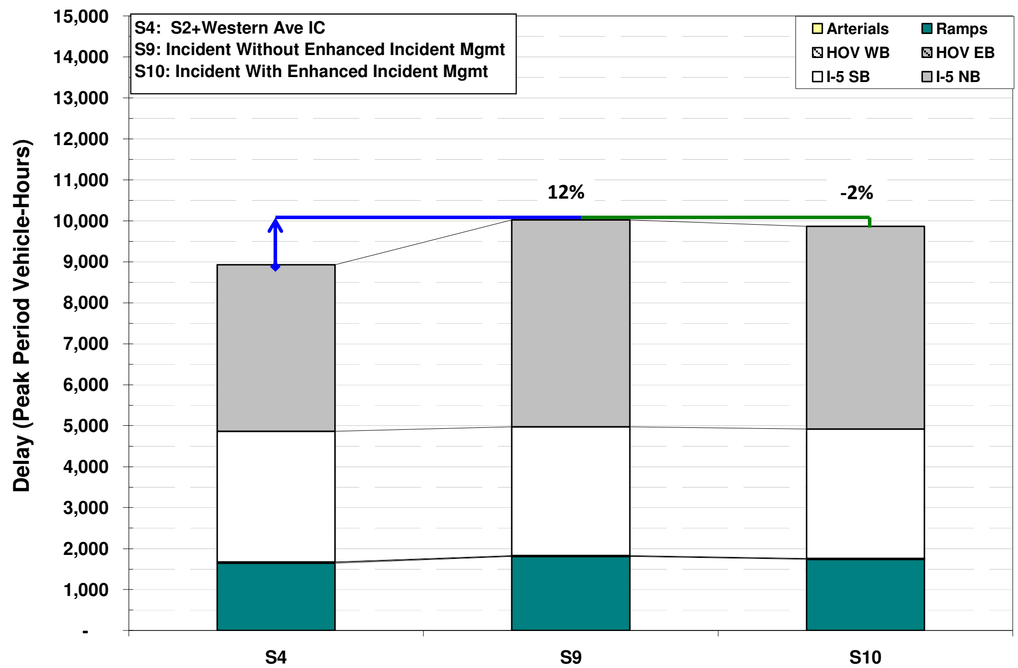


Exhibit 5-16: PM Delay Results for Enhanced Incident Management (2020)



Scenarios 11 (SR-134 HOV Connectors, Ramp Closure, I-405 HOV Connector)

Scenario 11 builds on Scenario 8 and tests several proposed longer-range capital improvement projects with only the 2020 model:

- Construct SR-134 HOV direct connectors
- Close the southbound Stadium Way exit and relocate the Fletcher Avenue exit to include Stadium traffic
- Eliminate one of the southbound lanes on the SR-2 connector on-ramp
- Construct an I-5/I-405 HOV connector.

The 2020 model shows that this group of projects while having nominal impact on delay in the AM peak is estimated to reduce delay by nearly 20 percent or almost 1,500 vehicle-hours in the PM peak.

Benefit-Cost Analysis

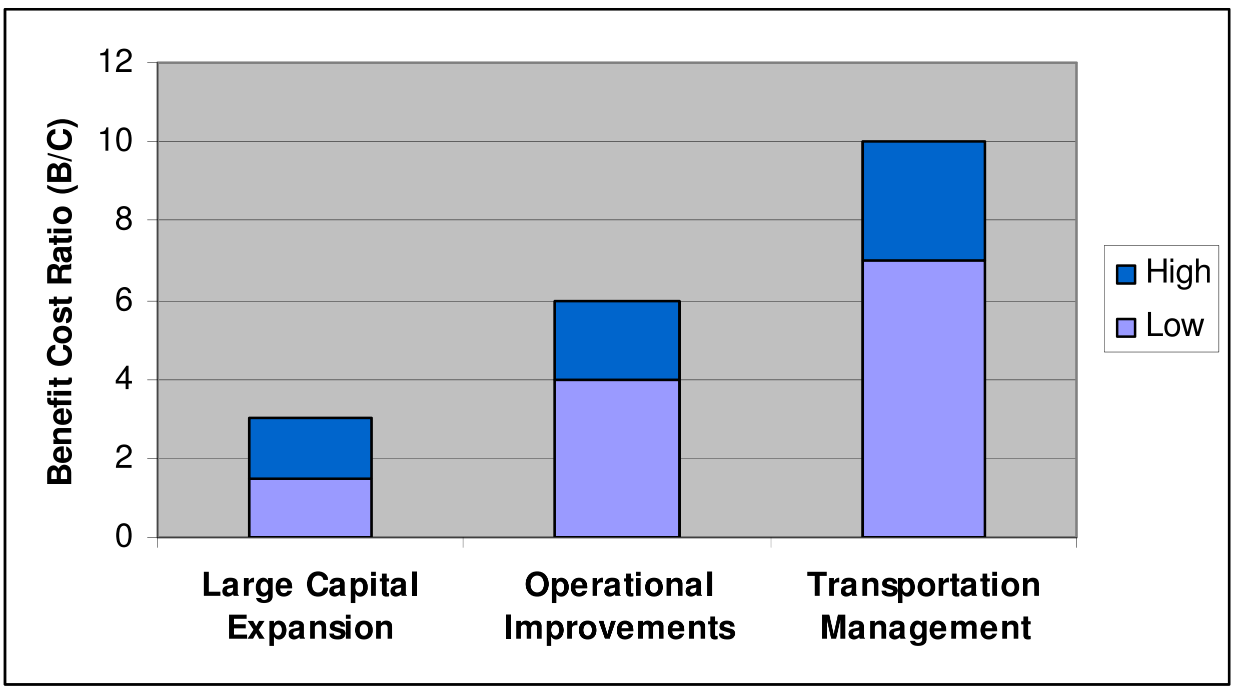
Following an in-depth review of the model results, the study team developed a benefit-cost (B/C) analysis for each scenario. The benefit-cost results represent the incremental benefits over the incremental costs of a given scenario.

The study team used the California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) developed by Caltrans to estimate benefits in three key areas: travel time savings, vehicle operating cost savings, and emission reduction savings. The results are conservative since this analysis does not capture the benefits after the 20-year lifecycle or other benefits, such as the reduction in congestion beyond the peak periods and improvement in transit travel times.

Project costs were developed from SCAG and Caltrans project planning and programming documents. These costs include construction and support costs in current dollars. The study team estimated costs for projects that did not have cost estimates by reviewing similar completed projects. A B/C ratio greater than one means that a scenario's projects return greater benefits than they cost to construct or implement.

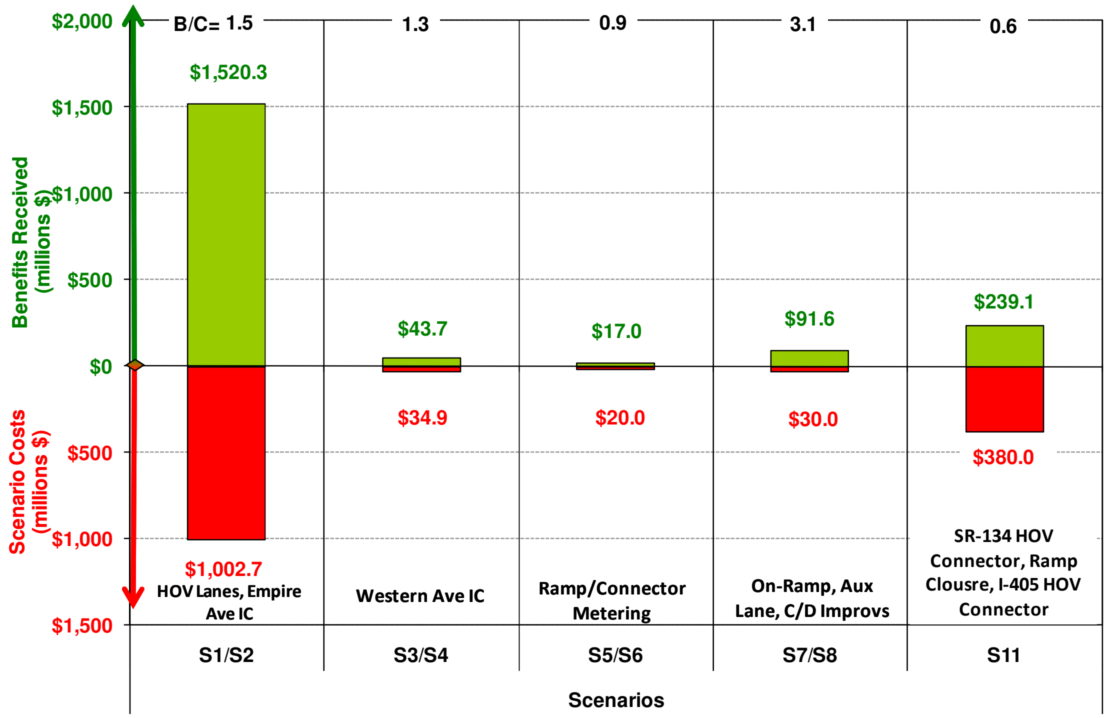
It is important to consider the total benefits that a project brings. For example, a large capital expansion project can cost a great deal and have a low B/C ratio, but brings much higher absolute benefits to I-5 users. Exhibit 5-17 illustrates typical benefit-cost ratios for different project types.

Exhibit 5-17: Benefit-Cost Ratios for Typical Projects



The benefit-cost analysis for the I-5 North corridor is summarized in Exhibit 5-18:

Exhibit 5-18: Scenario Benefit/Cost (B/C) Results



The benefit-cost findings for each scenario are as follows:

- Scenarios 1 and 2 (HOV lanes + Empire Avenue Interchange Modification) produce a B/C ratio of between one and two. This is consistent with other typical capital expansion projects.
- Scenarios 3 and 4 (Western Avenue Interchange) produce a relatively low benefit-cost ratio of less than two. With just a localized improvement, impact on the entire corridor is expected to be nominal. The project is expected to produce a greater impact to the local traffic circulation and operations that may not be fully realized by the model.
- Scenarios 5 and 6 (Advanced Ramp Metering) produce a relatively low benefit-cost ratio of about one. The mobility gains on the freeway mainline are offset by the increases in delay on the proposed metered connectors. Further analysis may need to be conducted for considering advanced ramp metering deployment along this corridor.
- Scenarios 7 and 8 (Operational Improvements) produce a relatively modest benefit-cost ratio of just over three as compared to other similar type projects. Still, mobility benefits of over 1,500 vehicle-hours daily delay reduction are estimated in 2020.

- Scenarios 11 (Long Range Capital Improvements) produces a relatively low benefit-cost ratio of less than one, primarily due to the high cost of the I-5/I-405 HOV lane connector project estimated at over $330 million.
- The benefit-cost ratio of all the scenarios combined is just over one. In current dollars, costs add up to $1.5 billion whereas the benefits are estimated to be almost $1.8 billion.
- In addition, the projects also alleviate green house gas (GHG) emissions by almost one million tons over 20 years, averaging almost 50,000 tons reduction per year.

Detailed benefit-cost results can be found in Appendix B.

6. CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions and recommendations based on the analysis in the previous section. Many of these conclusions are based primarily on the micro-simulation model results. The model was developed based on the best data available at the time. The study team believes that the calibrated base year model, the forecast year model, and the scenario results are reasonable. However, caution should always be used when making decisions based on modeling alone, especially complex models such as this one.

Based on the results, the study team offers the following conclusions and recommendations:

- The combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is above 2007 levels in the AM but well below 2007 levels in the PM peak period. In the AM peak period, the model projects total delay in 2020 after delivering all projects to be around 4,300 hours compared to the 2007 base year delay of 3,150 hours. This represents an increase of approximately 35 percent. In the PM peak period, the model projects total delay in 2020 after delivering all projects to be around 6,700 hours compared to the 2007 base year delay of almost 12,000 hours. This represents a reduction of almost 50 percent. Clearly, the scenarios deliver significant mobility benefits to the corridor. Despite the growth in demand, future 2020 congestion will be less than experienced in 2007.
- Due to the high cost of the HOV expansion projects in Scenarios 1 and 2, the overall benefit-cost ratio is between one and two meaning that for every investment dollar spend the region will get more than one dollar in benefits. However, the improvements in mobility, particularly in the most heavily congested segments along the corridor, are significant. While substantial mobility improvements are realized in the northbound direction along the entire corridor, the improvements along the southbound corridor are negated by the delay increase in the downstream segments where the proposed HOV lane terminates. An HOV lane extension may need to be considered for the long term.
- The Western Avenue interchange improvements also produced an overall benefit-cost ratio of over one. While the benefits along the freeway corridor are limited by a single point improvement, greater benefits to the local arterials that are not fully captured by the model are expected.
- Advanced ramp metering only brings modest mobility improvements on the corridor. Further analysis with additional measures such as various ramp and interchange modifications may need to be conducted and evaluated in considering advanced ramp metering deployment.

- Operational improvements such as auxiliary lanes and ramp improvements, combined with advanced ramp metering, could leverage on the programmed capital expansion projects by making the corridor more efficient and productive that could result in additional mobility benefits of nearly $100 million.
- Enhanced incident management strategies associated with Scenarios 9 and 10 to address non-recurrent congestion show promise with a delay reduction of over 700 vehicle-hours for one modest level incident with a typical duration of 35 minutes reduced to 25 minutes. With the I-5 North corridor experiencing over 2,000 collisions per year, this would amount to a total annual delay savings of approximately 1.4 million vehicle-hours for the study corridor.
- Long-range capital improvements included in Scenarios 11 are expected to produce relatively modest improvements in mobility with a nominal benefit to cost ratio, primarily due to the high cost of the I-5/I-405 HOV lane connector project estimated at over $330 million.

Speed Contour Maps

Exhibits 6-1 through 6-4 show the speed contour maps for the 2020 horizon year baseline (do minimum). For the northbound direction, the peak is in the PM. For the southbound direction, the peak is also in the PM. Exhibits 6-5 and 6-6 illustrate the speed contour maps produced by the model at the conclusion of Scenario 11, the final scenario tested. The exhibits show the last remaining residual congestion and bottleneck locations in the PM peak for both directions. As indicated, there is very little noticeable congestion by year 2020 for the northbound model after all of the scenarios are implemented. For the southbound model, there is still noticeable congestion approaching the SR-134 and the SR-110, although speeds have increased overall.

This is the first generation CSMP for the I-5 corridor. It is important to stress that CSMPs should be updated on a regular basis. This is particularly important since traffic conditions and patterns can differ from current projections. After projects are delivered, it is also useful to compare actual results with estimated ones in this document so that models can be further improved as appropriate.

CSMPs, or a variation thereof, should become the normal course of business that is based on detailed performance assessments, an in-depth understanding of the reasons for performance deterioration, and an analytical framework that allows for evaluating complementary operational strategies that maximize the productivity of the current system.

Exhibit 6-1: Northbound AM Peak Model Speed Contours at Baseline (2020)

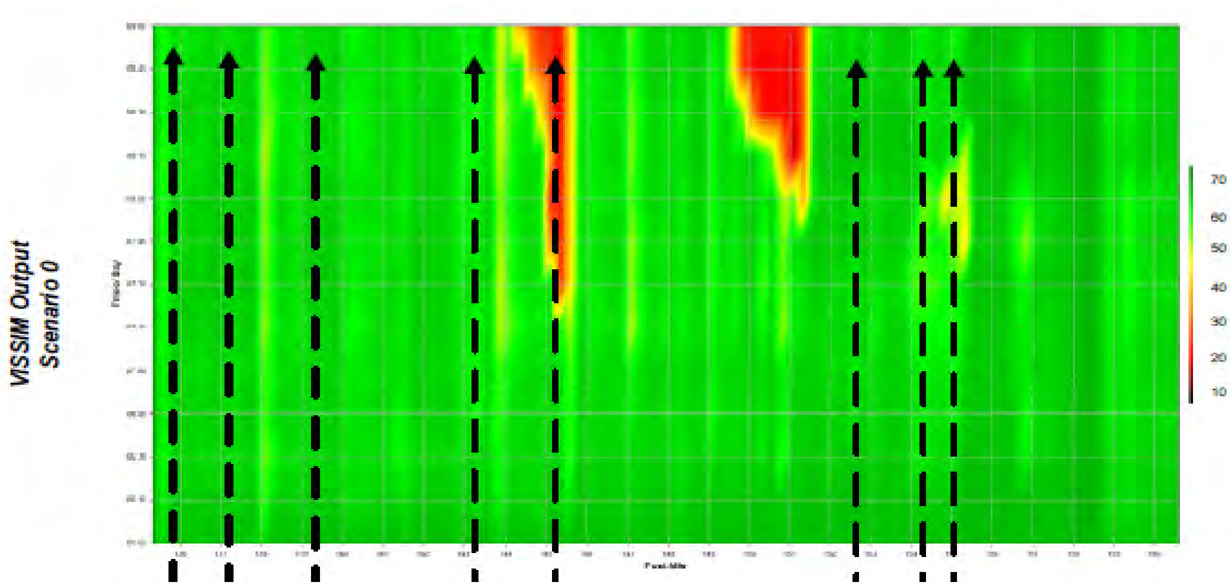


Exhibit 6-2: Northbound PM Peak Model Speed Contours at Baseline (2020)

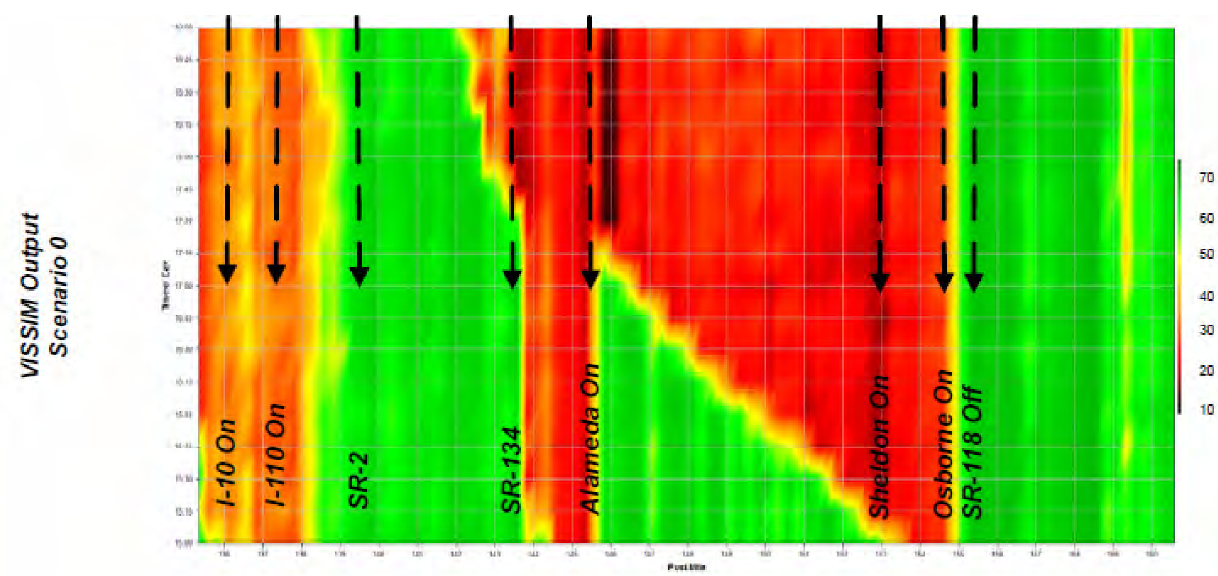


Exhibit 6-3: Southbound AM Peak Model Speed Contours at Baseline (2020)

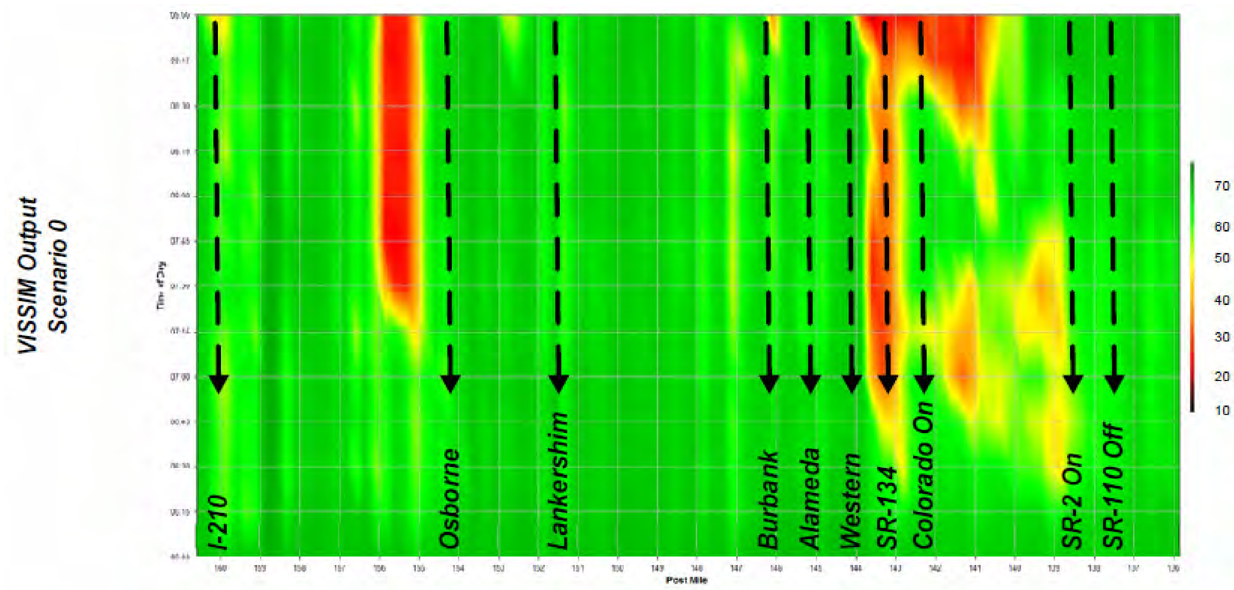


Exhibit 6-4: Southbound PM Peak Model Speed Contours at Baseline (2020)

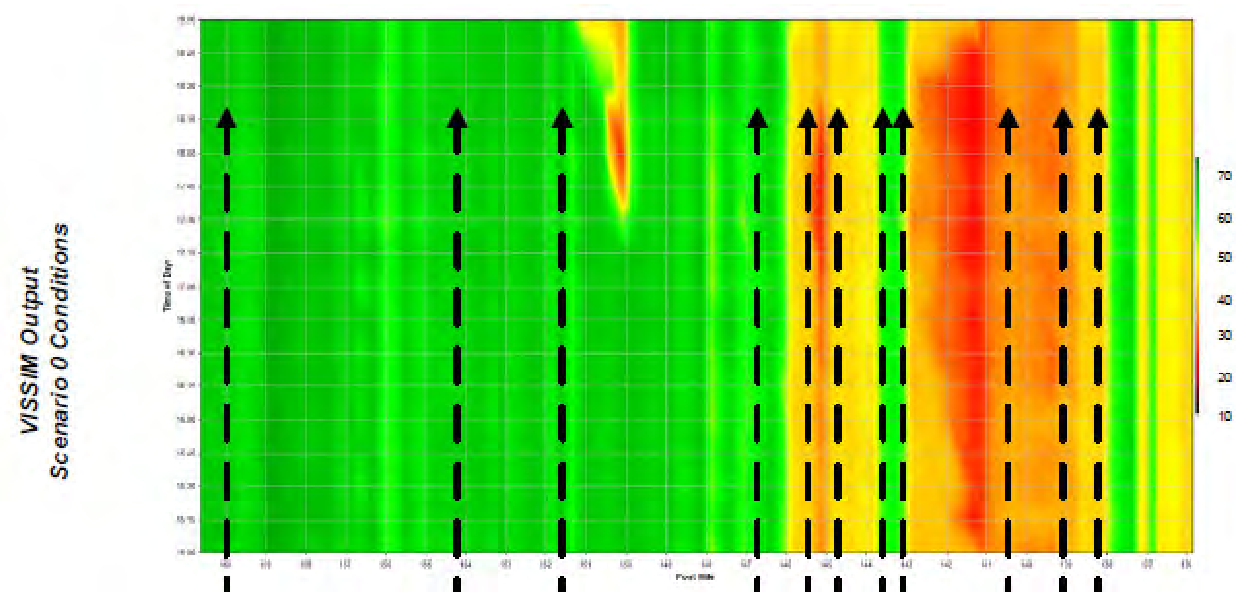


Exhibit 6-5: Northbound PM Peak Model Speed Contours After Scenario 11 (2020)

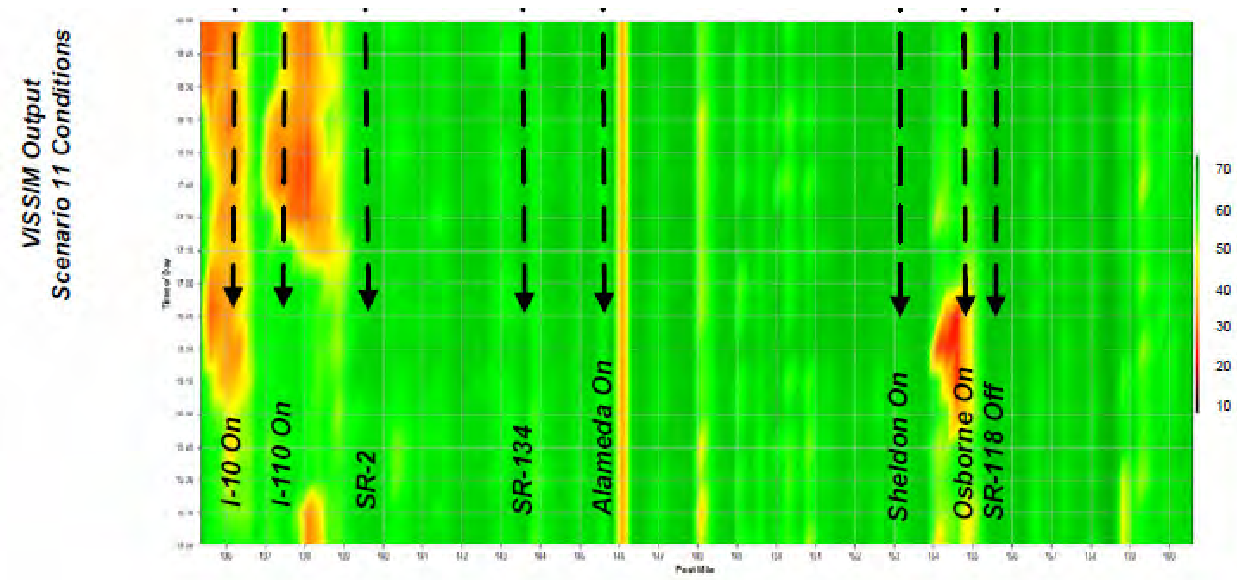
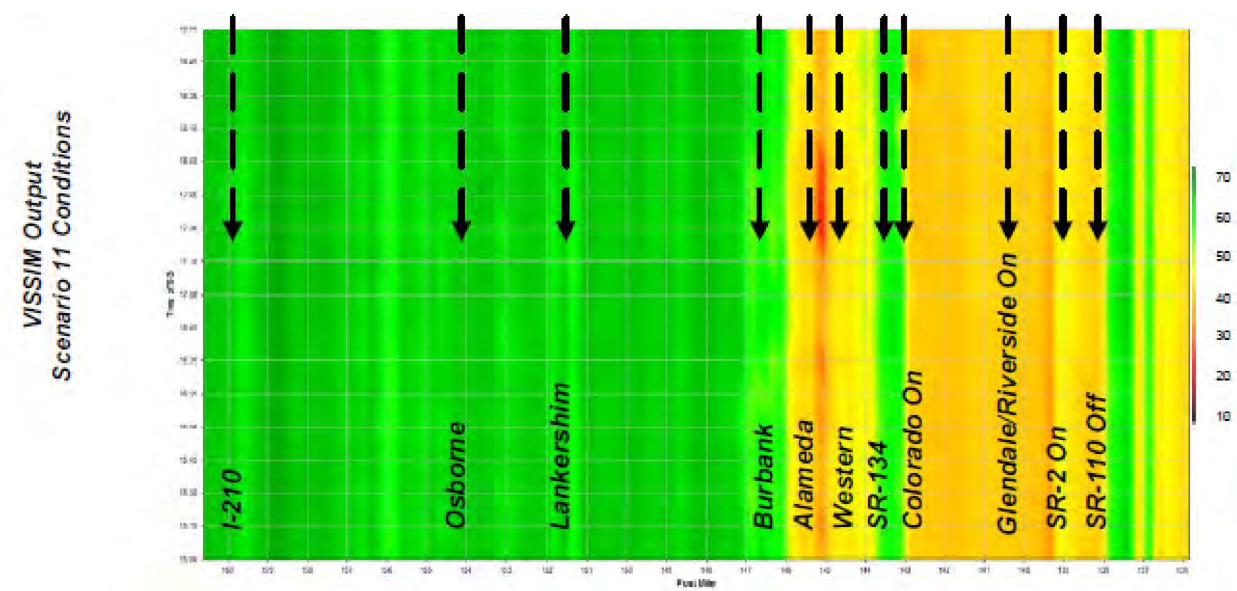


Exhibit 6-6: Southbound PM Peak Model Speed Contours After Scenario 11 (2020)



Appendix A: I-5 North Detailed Scenario Descriptions

Scenario	Proj ID	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
1 (2007-1) 2 (2020-1)	LA01344 LA0D192 EA 12200	From Rt 118 to Rt 14 from 10 to 12 lanes HOV lanes	CALTRANS	COMPL 2008	06 & 08 RTIP	$55,057
	LA000358 LA996375 EA 1218V EA 12182 EA 12183 EA 12184	• From Rte 134 to Rte 170 HOV lanes from 8 to 10 lanes. • Construct modified IC at I-5 Empire Ave; aux lanes NB & SB between Burbank Bl & Empire Ave	CALTRANS	2011	06 & 08 RTIP CMIA	$724,249
	LA000357 EA 12190	From Rte 170 to Rt 118, add one HOV lane in each direction (10 to 12 lanes) including the reconstruction of the I-5/SR-170 mixed flow connector and the construction of the I-5/SR-170 HOV to HOV connector	CALTRANS	2011	06 & 08 RTIP	$223,410
3 (2007-2) 4 (2020-2)	LA0C8012 EA 1786A	Western Ave IC phase I -realignment of I-5 NB off & on ramps at Western. NB exit ramp begins as 2 and widens to 4 lanes at Flower St.	CALTRANS	2011	06 & 08 RTIP	$34,907
	17860	Between Sonora Ave and Allen St - Modify Rte 5/Western Ave IC (realigning the 8 existing on & off ramps).	GLENDALE	2011	06 & 08 RTIP	
5 (2007-3) 6 (2020-3)	Proposed (SMG)	Advanced Ramp Metering using ALINEA API on entire corridor with queue control				$20,000
		Connector meter SR-118 connector on				
		Connector meter SB SR-2 connector on				

** Total cost includes construction and support costs in current dollars*

Scenario	Proj ID	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
7 (2007-4) 8 (2020-4)	Proposed (SMG)	Extend NB I-10 on-ramp to improve merging				$30,000
		Modify Pasadena on-ramp to merge into new C/D (from Broadway) and move on-ramp merge downstream				
		Modify Riverside Drive on-ramp to northbound SR-110 on-ramp; reduce the SR-110 merge to one lane before merge with northbound I-5				
		Restripe to solid white 1000 feet past SR-134 on merge point and move connector (2nd lane) lane drop upstream				
		NB I-5: Modify Alameda IC to eliminate C/D				
		NB I-5: Modify Sheldon IC to eliminate C/D				
		Carry fourth SB lane through the SR-2 IC				
9 (2020-5) 10 (2020-6) -Builds on Sc 4	Proposed (SMG)	Test Improvements to Incident Management				$ 10,000
11 (2020-7)	Proposed (SMG)	SR-134 HOV direct connectors				$50,000
		Close SB Stadium Way exit and relocate Fletcher exit (to include Stadium traffic)				
		Eliminate one of the SB lanes on SR-2 connector on				
	1H0103 EA 17610K	I-5/I-405 HOV lane connector	LA Metro	2029	08 RTP Metro LRTP	$330,000

** Total cost includes construction and support costs in current dollars*

Appendix B: Benefit-Cost Analysis Results

This appendix provides more detailed Benefit-Cost Analysis (BCA) results than found in Section 5 of the I-5 North Corridor System Management Plan (CSMP) Final Report. The BCA results for this CSMP were estimated by using the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) Version 4.0* developed for Caltrans by System Metrics Group, Inc. (SMG).

Caltrans uses Cal-B/C to conduct investment analyses of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP), and other ad hoc analyses requiring BCA. Cal-B/C is a spreadsheet-based tool that can prepare analyses of highway, transit, and passenger rail projects. Users input data defining the type, scope, and cost of projects. The model calculates life-cycle costs, net present values, benefit-cost ratios, internal rates of return, payback periods, annual benefits, and life-cycle benefits. Cal-B/C can be used to evaluate capacity expansion projects, transportation management systems (TMS), and operational improvements.

Cal-B/C measures, in constant dollars, four categories of benefits:

- Travel time savings (reduced travel time and new trips)
- Vehicle operating cost savings (fuel and non-fuel operating cost reductions)
- Accident cost savings (safety benefits)
- Emission reductions (air quality and greenhouse gas benefits).

Each of these benefits was estimated for the peak period for the following categories:

- **Life-Cycle Costs** - present values of all net project costs, including initial and subsequent costs in real current dollars.
- **Life-Cycle Benefits** - sum of the present value benefits for the project.
- **Net Present Value** - life-cycle benefits minus the life-cycle costs. The value of benefits exceeds the value of costs for a project with a positive net present value.
- **Benefit/Cost Ratio** - benefits relative to the costs of a project. A project with a benefit-cost ratio greater than one has a positive economic value.
- **Rate of Return on Investment** - discount rate at which benefits and costs are equal. For a project with a rate of return greater than the discount rate, the benefits are greater than costs and the project has a positive economic value. The user can use rate of return to compare projects with different costs and different benefit flows over different time periods. This is particularly useful for project staging.

- **Payback Period** - number of years it takes for the net benefits (life-cycle benefits minus life-cycle costs) to equal the initial construction costs. For a project with a payback period longer than the life-cycle of the project, initial construction costs are not recovered. The payback period varies inversely with the benefit-cost ratio. A shorter payback period yields a higher benefit-cost ratio.

The model calculates these results over a standard 20-year project life-cycle, itemizes each user benefit, and displays the annualized and life-cycle user benefits. Below the itemized project benefits, Cal-B/C displays three additional benefit measures:

- **Person-Hours of Time Saved** - reduction in person-hours of travel time due to the project. A positive value indicates a net benefit.
- **Additional CO_2 Emissions (tons)** -additional CO_2 emissions that occur because of the project. The emissions are estimated using average speed categories using data from the California Air Resources Board (CARB) EMFAC model. This is a gross calculation because the emissions factors do not take into account changes in speed cycling or driver behavior. A negative value indicates a project benefit. Projects in areas with severe congestion will generally lower CO_2 emissions.
- **Additional CO_2 Emissions (in millions of dollars)** - valued CO_2 emissions using a recent economic valuing methodology.

A copy of Cal-B/C v4.0, the User's Guide, and detailed technical documentation can be found at the Caltrans' Division of Transportation Planning, Office of Transportation Economics website at http://www.dot.ca.gov/hq/tpp/offices/ote/benefit.html.

The exhibits in this appendix are listed as follows:

- Exhibit B-1: BCA Results - S1/S2 HOV Lanes + Empire Ave IC Modification
- Exhibit B-2: BCA Results - S3/S4 Western Avenue IC
- Exhibit B-3: BCA Results - S5/S6 Advanced Ramp Meter + Connector Metering
- Exhibit B-4: BCA Results - S7/S8 On-Ramp, Aux Lane, C/D Improvements
- Exhibit B-5: BCA Results - S11 SR-134 Connector + Ramp Closure + I-405 HOV Connector
- Exhibit B-6: Cumulative BCA Results.

Exhibit B-1: BCA Results - S1/S2 HOV Lanes + Empire Ave IC Modification

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,002.7
Life-Cycle Benefits (mil. $)	$1,564.1
Net Present Value (mil. $)	$561.4
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	8.3%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$64.5	$1,290.8
Veh. Op. Cost Savings	$9.9	$197.5
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.8	$75.8
TOTAL BENEFITS	$78.2	$1,564.1
Person-Hours of Time Saved	8,427,141	168,542,819
Additional CO_2 Emissions (tons)	-49,754	-995,072
Additional CO_2 Emissions (mil. $)	-$1.4	-$28.8

Incremental Costs (mil. $)	$1,002.7
Incremental Benefits (mil. $)	$1,564.1
Incremental Benefit / Cost Ratio:	1.6

Exhibit B-2: BCA Results - S3/S4 Western Avenue IC

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,037.6
Life-Cycle Benefits (mil. $)	$1,606.7
Net Present Value (mil. $)	$569.1
Benefit / Cost Ratio:	1.5
Rate of Return on Investment:	8.2%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$66.8	$1,336.8
Veh. Op. Cost Savings	$9.8	$195.2
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.7	$74.8
TOTAL BENEFITS	$80.3	$1,606.7
Person-Hours of Time Saved	8,739,515	174,790,291
Additional CO_2 Emissions (tons)	-49,521	-990,425
Additional CO_2 Emissions (mil. $)	-$1.4	-$28.6

Incremental Costs (mil. $)	$34.9
Incremental Benefits (mil. $)	$42.6
Incremental Benefit / Cost Ratio:	1.2

Exhibit B-3: BCA Results - S5/S6 Advanced Ramp Meter + Connector Metering

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,057.6
Life-Cycle Benefits (mil. $)	$1,623.8
Net Present Value (mil. $)	$566.2
Benefit / Cost Ratio:	1.5
Rate of Return on Investment:	8.2%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$67.6	$1,352.2
Veh. Op. Cost Savings	$9.8	$196.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.8	$75.4
TOTAL BENEFITS	$81.2	$1,623.8
Person-Hours of Time Saved	8,817,727	176,354,534
Additional CO_2 Emissions (tons)	-49,931	-998,612
Additional CO_2 Emissions (mil. $)	-$1.4	-$28.9

Incremental Costs (mil. $)	$20.0
Incremental Benefits (mil. $)	$17.1
Incremental Benefit / Cost Ratio:	0.9

Exhibit B-4: BCA Results - S7/S8 On-Ramp, Aux Lane, C/D Improvements

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,087.6
Life-Cycle Benefits (mil. $)	$1,715.0
Net Present Value (mil. $)	$627.3
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	8.5%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$71.8	$1,436.4
Veh. Op. Cost Savings	$10.1	$202.5
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.8	$76.1
TOTAL BENEFITS	$85.7	$1,715.0
Person-Hours of Time Saved	9,348,729	186,974,581
Additional CO_2 Emissions (tons)	-51,643	-1,032,860
Additional CO_2 Emissions (mil. $)	-$1.5	-$29.8

Incremental Costs (mil. $)	$30.0
Incremental Benefits (mil. $)	$91.1
Incremental Benefit / Cost Ratio:	3.0

Exhibit B-5: BCA Results - S11 SR-134 Connector + Ramp Closure + I-405 HOV Connector (Incremental)

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$380.0
Life-Cycle Benefits (mil. $)	$239.1
Net Present Value (mil. $)	-$140.9
Benefit / Cost Ratio:	0.6
Rate of Return on Investment:	-0.7%
Payback Period:	20+ years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$12.4	$247.6
Veh. Op. Cost Savings	-$0.3	-$5.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	-$0.2	-$3.3
TOTAL BENEFITS	$12.0	$239.1
Person-Hours of Time Saved	1,492,080	29,841,599
Additional CO2 Emissions (tons)	1,142	22,831
Additional CO2 Emissions (mil. $)	$0.0	$0.7

Exhibit B-6: Cumulative BCA Results

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,467.6
Life-Cycle Benefits (mil. $)	$1,954.1
Net Present Value (mil. $)	$486.5
Benefit / Cost Ratio:	1.3
Rate of Return on Investment:	n/a
Payback Period:	n/a

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$84.2	$1,684.1
Veh. Op. Cost Savings	$9.9	$197.2
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.6	$72.8
TOTAL BENEFITS	$97.7	$1,954.1
Person-Hours of Time Saved	10,840,809	216,816,180
Additional CO_2 Emissions (tons)	-50,501	-1,010,029
Additional CO_2 Emissions (mil. $)	-$1.5	-$29.1